CHAPTER 4: PREVENTION IS BETTER THAN CURE: IMPLEMENTING SOIL CONSERVATION PRACTICES MAY BE CHEAPER THAN DREDGING

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1. Abstract

Assessing changes in the provisioning of ecosystem services (ES) due to changes in agroecosystem management will better inform Costa Rican PES escheme. This scheme is recognizing the role of agroecosystem as ES providers, still an assessment of the provisioning of ES by implementing ideal cropping systems (combination of at least two or three soil conservation practices) rather than only spread trees is missing. One of the most critical ES provided in agroecosystems is soil retention, this ES have on-site benefits for the farmer and off-site benefits for downstream consumers such as hydropower companies. We estimated changes on soil retention ES by implementing ideal cropping systems in three of the most important basins for hydropower and agricultural production in the Upper-Middle Reventazon watershed in Costa Rica. We tested three targeting strategies, four budgets allocations and compared the avoided cost of dredging the retained soil with current dredging cost. We quantified the provision of the soil retention ES using the Integrated Valuation of Environmental Services (InVEST). We used the Tradeoffs and the Resources Investment Optimization System (RIOS) to test our three targeting strategies: (1) RIOS default optimization, (2) RIOS constrained to current land uses in conflict with soil legislation and (3) RIOS constrained to erosive crops and crops on steep slopes. The tested budget included the lowest budget allocated in the watershed for soil conservation programs in the past up to the maximum amount it will be requiered to implement ideal cropping systems across all the agricultural land. Our results indicate that targeting efforts on erosive crops or crops on steep slopes will likely provide the highest cost-effectiveness investment scenario, or in other words, the highest soil retention per dollar spent. Under this particular targeting strategy, investments in ideal cropping systems may be more cost effective than dredging sediment from the downstream

reservoirs, given our modeling assumptions. Our modeling strategy, offers a conservative and simple but robust first approximation to a methodology that can be adapted and modeled iteratively to assess ES provisioning due to changes in agroecosystems management.

2. Introduction

Agroecosystems production and sustainability along with forest conservation should be top priorities for Costa Rica (Hall et al., 2000). Approximately 35% of Costa Rica land for food production has poor management practices (Vignola et al., 2010; CADETI, 2004). Poor management practices impacts the national economy with an estimated reduction of 7.7% of the agriculture gross domestic product due to soil erosion and nutrient depletion (MINAE 2002). Costa Rica consumes 4-8 times more fertilizers, particularly nitrogen and potash, than the average Latin America country (FAO, 2013). High amounts of fertilizers are required to compensate for the high erosion rates that probably are exceeding soil formation rates in most of the agricultural land (Rubin & Hyman, 2000). In addition to the loss of crop productivity from soil loss, the transport and accumulation of sediment has further economic implication for downstream reservoirs for hydropower (Vignola et al., 2008). Hydropower is the main source of energy in Costa Rica, constantly challenged by the high sediment loads and pollution into upstream reservoirs (Haun et al., 2013; Brandt & Swenning, 1999). Besides, high sediment loads reduce the life span of dams by rapid infilling (Haun et al., 2013). Pollution (source and non-source) from agriculture production affects water quality, riparian habitats and aquatic communities (Echeverría-Sáenz et al., 2012).

Efforts to protect soil (and the services it provides) are weaker than the efforts to protect forest cover (and the services it provides) in Costa Rica. Forest cover area in Costa Rica is slightly increasing (FAO, 2013) while soil is being depleted (MINAE 2002). The increase of forest cover is due to a combination of factors such as the creation and enforcement of the Forestry Law 7575 in 1997 which forbids deforestation while promotes incentive-based conservation via payment for environmental

services (PES) schemes; besides other external factors such as the increase of ecotourism and the reduction of cattle ranch profitability (Robalino & Pfaff, 2013). The Soil Law 7779 created in 1998 has a poor enforcement that has led to poor conditions, law inconsistencies and constrained budgets that weakened agricultural extension offices, key organizations transmitting information, technology and sustainable soil conservation practices (Vignola et al., 2013; Vignola et al., 2010). Hydropower companies, an industry highly dependent and affected by water quality, has been also promoting environmental education (Blackman & Woodward, 2010), supporting soil conservation management (Vignola et al., 2012) and supporting watershed management plans (PREVEDA, 2008) to increase soil retention at the source. Also, major voluntary or non-voluntary (tax payments) investments to fund the PES scheme comes from hydropower companies to improve the provision of hydrological services and extend the life span of the dams: but most importantly to improve their relationship with local stakeholders (Blackman & Woodward, 2010).

Payment for ecosystem services (PES) scheme goals is to increase national forest cover to generate multiple ecosystem services (ES), such as hydrological services (particularly water quality), scenic beauty, carbon sequestration, and biodiversity (Pagiola, 2008). The PES scheme provides funds for forest protection, forest management, reforestation, and, recently, agroforestry. The recognition of agroforestry (only trees within agricultural land) in the Costa Rican PES scheme was an important step towards recognizing the role agroecosystems as ES providers. The total land area covered with PES for agroforestry has increased from 2% in 2003 to 12% in 2011 (FONAFIFO, 2014). Despite this increase, we still lack a quantified understanding of which practices guarantee ES provisioning at the site level and how site level implementations across a watershed improve larger scale services in agroecosystems, such as soil retention. Design efficacy and site prioritization of agroforestry practices becomes key component in designing PES programs that get what they pay for.

To curb soil loss from agroecosystems, many conservation practices (not only spread trees as current PES scheme) have proven to increase farm productivity while improving soil retention and water

quality (Dogliotti et al., 2013; Lenka et al., 2012; WOCAT, 2012; Cocchi & Bravo-Ureta, 2007; Alegre, & Rat, 1996). In Honduras, ground-cover technologies such as crop-mulch/residue management, green manure and conservation tillage led to an increase of farm income up to 20% (Cocchi & Bravo-Ureta, 2007). While in Chile, multi-year planning and farm redesign halved soil erosion rates (Dogliotti et al., 2013). Past experiences studying a PES scheme on degraded pastures in Costa Rica, Nicaragua and Colombia, indicated that implementing both, high density of trees and shrubs, improved rangeland productivity, biodiversity, carbon sequestration and water quality (Pagiola et al., 2005; Garbach et al., 2012). However, potential negative effects such as competition for nutrients and light, increase of diseases and seedlings suppression should also considered in full cost-benefit analyses (Alegre, & Rat, 1996). Vegetative conservation practices offer diverse ES and are as effective as physical or structural practices (particularly retaining soil) but are more cost-effective and more flexible (Bravo-Ureta et al., 2006; Maetens et al., 2012).

Farmer's voluntary implementation of conservation practices is limited by short-term needs, lack of information and lack of resources (Vignola et al., 2010). In addition, masking factors such as external inputs, soil deposition, deep soils and everyday contact also limits voluntary implementation (Lal, 2001, Vignola et al., 2012). However, a recent research in one of the most erosive and hydrological important watershed in Costa Rica indicated that farmers (ES providers) and hydropower companies (ES consumers) agreed on the need to change existent conditions in terms of land use and management towards a more sustainable (Vignola et al., 2008). Local stakeholders highlighted that efforts to promote the desired change should be targeted to high priority areas (Vignola et al., 2012).
To define which targeting strategy will be the most cost-effective, we used a coupled economic and soil loss model to evaluate multiple strategies for reducing soil loss and compared these estimates to the costs of dredging three reservoirs in the upper and middle part of the Reventazon River, Costa Rica. We estimated the effect of implementing soil conservation practices as a strategy to provide the ES soil retention under three targeting strategies and three budget levels. We were particularly

interested on two key questions. First, which targeting strategies, investment distribution and budget is the most effective to provide the ES soil retention? Second, at which point investments to provide the ES soil retention are cheaper than the cost dredging? To answer both questions, we conducted a literature review to select the most suitable practices according to the agroecological and productive conditions of the study area. We also conducted a meta-analysis to estimate the efficacy of each practice retaining soil. The Integrated Valuation of Environmental Services and Tradeoffs (InVEST) help us to estimate soil retention under current and the different targeting strategies at the watershed scale. And, we used the Resources Investment Optimization System (RIOS) tool to test three targeting strategies. Though excluded from our analysis all the transaction costs associated with implementation, we focused on establishment and maintenance cost of the soil conservation practices.

3. Methodology

3.1. Study area

The upper and middle part of the Reventazon watershed has an area of 139,644 ha and generates approximately 38% of the national energy, 25% of the consumed water in San José and 11% of the agricultural products for exportation (ProDUS, 2011). Our analysis covers the drainage area of three of the most important dams within the Reventazon: Cachi, Angostura and Birris (Table 4; Figure 15). In 2000, the government created legislation (Law Nº 8023, 2000) to regulate and promote the sustainable management of the watershed due to its importance to the national economy. The upper and middle part of the watershed developed a management plan to improve local capacity, risk management, environmental education and soil conservation particularly on highly erosive basins (PREVEDA, 2008). These efforts to reduce soil loss have had only marginal impacts and the watershed still has high level of erosion and pollution (PREVEDA, 2008).

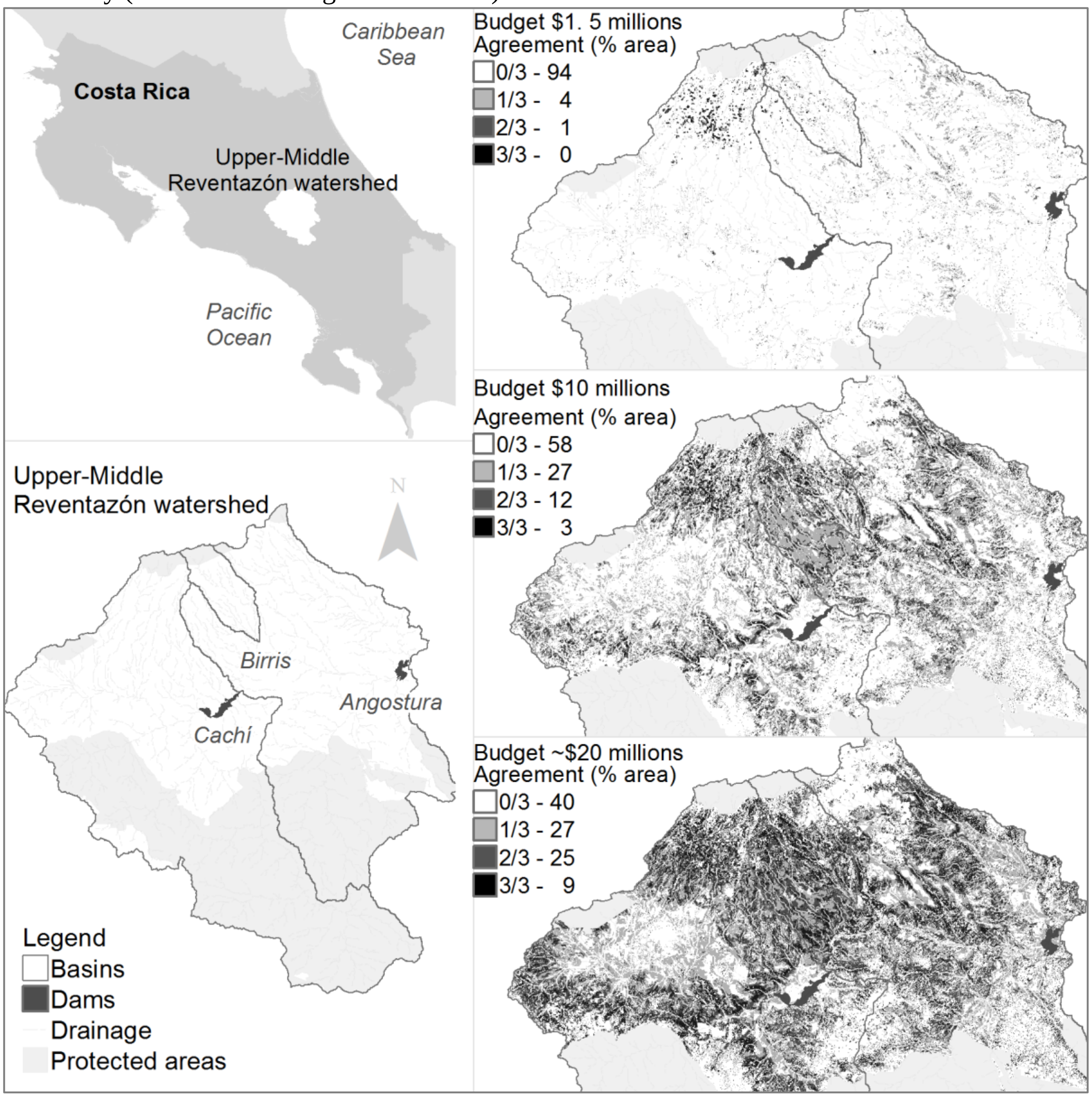
Table 4. Characteristics of the assessed dams in the Reventazon watershed. Assessment accuracy based on the comparison between the reported sediment yield to each reservoirs and the estimated exported sediment with InVEST.

	Starting	Current production (projected)	Capacity	Removal cost	Sediment yield	InVEST Exported Sediment	Accuracy Assessment		
							Sediment delivery ratio	Reported Soil loss	Estimated Soil loss
Dam/ Reservoir	year	MW	millions·m^3	\$millions·y^{-1}	\$millions·y^{-1}	\$millions·y^{-1}		t·ha^{-1}	t·ha^{-1}
Cachi/ ICE	1966	100 (160)	48*		1,1	3.5	0.32	26***	14
Birris/ JACEC	1990	4.3(13.6)			0.2	0.6	0.28	42***	42
Angostura/ ICE	2000	177	10.7**		1,5**	5.5	0.27	26****	26
Total				>2-4	2.8				

JASEC: Junta Administrativa del Servicio Eléctrico Municipal de Cartago
ICE: Instituto Costarricense de Electricidad
*The original volume is 54Mm^3, however, the latest estimation in 1993 indicated a volume loss of 11% of the original volume (Jiménez-Ramírez and Rodríguez-Mesa, 1992)
**The original volume is 11Mm^3, however, after two years of functioning the dam lost 2.5% of the original volume (Jiménez-Ramírez and Rodríguez-Mesa, 1992)
***Marchamalo (2004); Abreu (1994)
**** Vignola et al., (2010)

The Reventazon watershed is located on the Caribbean side of the Costa Rica mountain range (Figure 15), with annual precipitations ranging from 1,551 to 6,303 mm·y-1 with an average of 2,955 mm·y-1. The watershed is characterized by steep slopes in the upper and middle part of the watershed of altitudes ranging from 449 to 3,475 m.a.s.l and with an average slope of 21° (slope 37.5%). The watershed is largely covered with forest (51% of the total area), perennial crops (25%), pasture (16%) and semi-perennial and annual crops (5%). Coffee and sugarcane are the dominant perennial and semi-perennial crops. Forest cover has been constant through time the Reventazon watershed, but pastures, urban and sugarcane areas are increasing by replacing coffee and shrubland areas (Brenes, 2009).

Figure 15. The left panel shows the location of the Upper – Middle Reventazon watershed and the drainage area of the dams. The right panel shows the distribution of the targeted areas and the level of agreement across the three targeting strategies: 1) RIOS, 2) RIOS&Legislation and 3) RIOS&C-S. The level of agreement indicates which areas were targeted (or not) by the strategies. For example, with a budget of $1.5 millions, ninenty four percent of the area was excluded from all three targetting strategies to implement ideal croping systems and, all the three strategies allocated the budget differently (3/3 – 0% of the agricultural land).



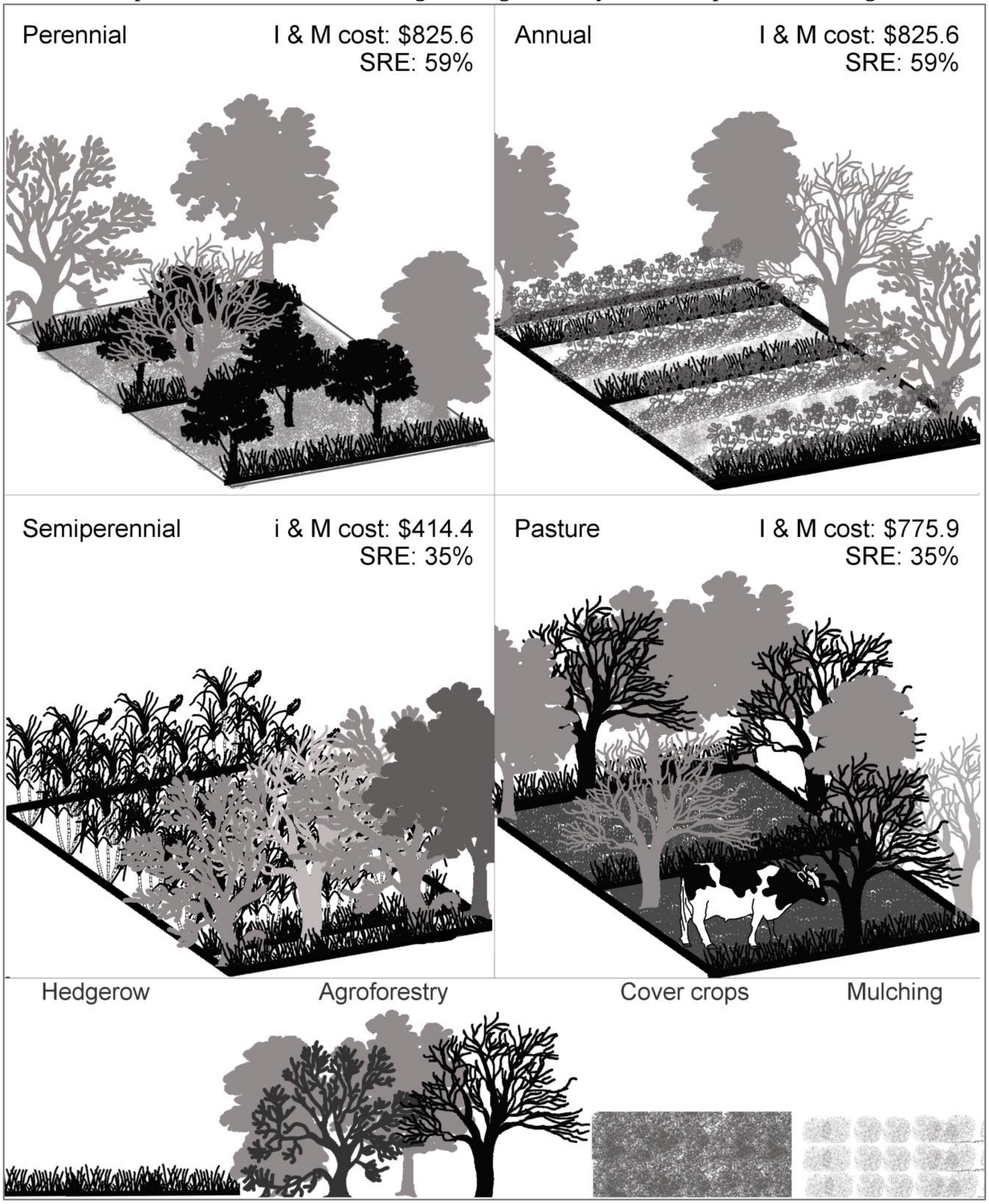
3.2. Activities: Ideal cropping systems – coupled soil conservation practices

Agroforestry is supported by the PES scheme to increase the number of trees within agricultural land (FONAFIFO, 2014). Spread trees can particularly provide ES such as scenic beauty, carbon

sequestration and biodiversity (Harvey et al., 2006; Perfecto et al., 2008). However, to particularly provide hydrological services, other soil conservation practices should be considered. In this modeling effort, we incorporated other vegetative soil conservation practices that minimize soil loss and maintain agricultural production, with lower implementation cost than engineered structures (Bravo-Ureta et al., 2006; Maetens et al., 2012). For each selected soil conservation practice we completed a literature review to list the pros and cons (Supplemental Material I) and to estimate the cost of implementation and the soil retention efficiency (Figure 16).

The Program for Sustainable Agriculture in Steep-lands in Central America (PASOLAC) systematized, revised and validated promising soil conservation practices using Honduras, Nicaragua and El Salvador farmers, technicians and organizations' knowledge and experience (PASOLAC, 2000). We used this dataset and selected the most suitable soil conservation practices for the agroecological and production conditions of the Reventazon. Four main soil conservation practices were selected: mulch, herbaceous hedgerows, agroforestry systems (low and high density) and cover crops or intercropping (Figure 16). In the Reventazon watershed farmers are already familiar with these selected practices (Vignola et al., 2010) which are actively being promoted by the watershed management plan (COMCURE, 2009). In our analysis we also assessed the combined effect of coupling multiple of the soil conservation practices (termed ideal cropping systems). Coupled practices were based on previous research (WOCAT, 2012; Vignola et al., 2010; Raudes & Sagastume 2009; COMCURE, 2009; FAO 2000 and 2001,) (Figure 16).

Figure 16. Ideal cropping systems or activities implementation and maintenance cost per hectare (I & M) estimated as the sum of each soil conservation practices implementation and maintenance cost (**¡Error! No se encuentra el origen de la referencia.**). Soil retention efficacy (SRE) estimated as the sum of the minimum reported efficacy for each soil conservation practice. Legend of the soil conservation practices at the bottom: Hedgerow, agroforestry, cover crops and mulching.



Each soil conservation practice has important pros and cons, and factors that limit their efficacy trapping soil and the adoption by individual farmers (**¡Error! No se encuentra el origen de la referencia.**). For example, soil conservation practices might limit the ability of machinery to enter the field or a practice could increase crop management complexity or increase shade area thereby increase pest risk (Raudes & Sagastume 2009). In addition, the specific crop, be it annual, perennial or semi-perennial, impacts the possible combinations of soil conservation practices. For example, burning is practiced in the region to harvest sugar cane (semi-perennial); therefore, hedgerows with trees in lineal arrangement are advocated over intermixed plantings. We considered these factors to design our ideal cropping systems and to model the effect of implementing those as a strategy to minimize soil loss. For example, cover crops or mulch will protect the soil from detachment, but if detached, hedgerows downslope will potentially retain it and agroforestry systems will promote deeper roots and grater infiltration rates (Supplemental Material I). We implemented ideal cropping systems on current perennial, annual, semi-perennial and pasture land cover types. But, we implemented reforestation with endangered tree species on bare soil cover type rather ideal cropping systems.

Implementation and maintenance cost for each one of the soil conservation practices were adopted from PASOLAC (2000) and updated to Costa Rican wages and prices (**¡Error! No se encuentra el origen de la referencia.**). Seed costs were obtained from a tropical research center in Costa Rica (CATIE) seed bank prices and the cost of the tree seed species correspond to the tree endangered species promoted according to Costa Rican legislation. The cost of implementing hedgerow increases with the slope steepness, so we estimated the total cost for each ideal cropping as the sum of each soil conservation practice cost on level (<15%), moderate (15-30%) and steep (>30%) slopes and used the averaged total cost across slope steepness (**¡Error! No se encuentra el origen de la referencia.**). The cost of reforestation with endangered tree species equals the payment that FONAFIFO is currently (2014) assigning to this activity ($1,470). Our cost of implementing and maintaining ideal cropping systems do not include cost associated with running and maintaining a PES program. This includes

transaction, training and opportunity costs. Targeting efforts to a small portion of the landscape will decrease transaction and monitoring costs, yet without a quantification of these costs, this analysis should not be considered a complete program analysis (Garrick et al., 2013).

The soil retention efficacy by each conservation practice and coupled practices were estimated from a meta-analysis. We searched in ScienceDirect using keywords such as "mulch" & "soil loss", “cover crops" & "soil loss", "hedgerow" & "soil loss" and "agroforestry" & "soil loss". We found 30 articles and 105 observations that reported the soil retention efficacy of specific soil conservation practices (the difference in measured soil loss with and without the soil conservation practice; 0% no retention and 100% maximum retention) (**¡Error! No se encuentra el origen de la referencia.**). We performed an analysis of variance (ANOVA) to test differences in soil retention efficacy between practices across slope ranges. The ANOVA indicated that agroforestry and agroforestry combined with hedgerow have significantly lower soil retention efficacy (36% and 43%, respectively) (p-value = 0.042). There were no significant differences between the other practices and at the different slopes categories.

We use a conservative method to estimate the soil retention efficacy of each soil conservation practices and ideal cropping systems due to the high variability among experiments and the lack of clear trends. We used the minimum reported value across the 105 observations for each practice (**¡Error! No se encuentra el origen de la referencia.**). We assumed that the interaction and retention efficacy among soil conservation practices in the ideal cropping system was additive; and therefore, we estimated the total soil retention efficacy of each ideal system as the sum of the minimum reported soil retention for each soil conservation practice (Figure 16, **¡Error! No se encuentra el origen de la referencia.**). In this study we only assessed soil retention as an ES; however, vegetative practices can also improve water regulation, nutrient cycling and biological control among other ES at the plot scale (Comerford et al., 2013). At larger scales, increase forest cover can improve habitat connectivity (Martínez-Salinas

& DeClerck, 2010), food security and human nutrition (DeClerck et al., 2011) and reduce vulnerability to extreme events (Altieri, 2002; Holt-Giménez, 2002).

3.3. Tools: Integrated Valuation of Environmental Services and Tradeoffs (InVEST) and Resources Investment Optimization System (RIOS)

Our metric for ecosystem service provision was soil retention, or in other words, the reduction of the exported soil off site by implementing the ideal cropping systems, estimated with InVEST and RIOS. InVEST and RIOS were developed by the Natural Capital Project and are complementary tools to assess ecosystem services. InVEST determines the quantity or presence of an ecosystem service; while RIOS identifies priority areas where changes on land use management to protect or restore an ecosystem service are potentially more cost-effective (Sharp et al., 2013; Vogl, et al., 2013). Soil retention was estimated as the difference between the estimated exported soil with InVEST under current conditions and the three targeting strategies we explored using also three budget levels with RIOS, over the current conditions' exported soil. Our analysis only included agricultural lands available to ideal cropping systems (53% of the watershed [73,441 ha] area). For instance we excluded protected areas, forest, urban, or water bodies, as well as areas classified as clouds or shadows.

RIOS identifies the areas that are more cost-effective retaining soil by combining information about the user desired activities (i.e. soil conservation practices), the cost of implementing each activity, the user´s available budget and the critical factors determining potential effectiveness retaining soil such as the contributing area, crop management (Factor C), riparian continuity restoration among others (Table 5) (Vogl et al., 2013). The critical factors determining soil loss come from a detailed review of literature and hydrological experiments and models; however, the user can modify the goal and weight of each critical factor according to local conditions (maximize or minimize), exclude factors from the analysis or use the defaults values as we did (Table 5) (Vogl et al., 2013). RIOS scores each pixel potential effectiveness for retaining soil as the weighted sum of each one of the critical factors values per activity (i.e. Figure 16), then, the cost of an activity is assigned to each pixel for all the included

activities. This is done to allocate the budget yielding the biggest return on investment; therefore, the priority areas for an activity will potentially yield the greatest benefit at the lowest cost (Vogl et al., 2013).

Table 5. Critical factors consider by RIOS to score each pixel's potential effectiveness retaining soil.

Category	Factors determine effectiveness	Goal	Weight	Description	Calculated from (by who):
Upslope Source Index	Upslope retention index	Maximize	1	Estimates the contributing area to a pixel and the magnitude of the contribution	Flow accumulation, pixels sediment export coefficients, retention factors, slope (RIOS)
Downslope Retention Index	Downslope index	Minimize	1	Estimates potential retention downslope of a pixel	Flow length, slope, retention factors (RIOS)
On-pixel source:	Sediment export coefficient	Maximize except for transition keep native veg (Minimize)	0.25	Factor C in USLE. Indicates the impacts of previous cropping systems, the protection offered to the soil surface by vegetative canopy, erosion reduction due to surface cover, and surface roughness	Obtained from literature review or by measuring surface cover, mass density of superficial roots, effectiveness of surface cover; mass density of incorporate surface residue, surface soil consolidation factor, surface roughness; canopy height, surface roughness, fraction of land surface covered by canopy impacts of the subsurface residues (USER)
On-pixel source:	Erosivity factor	Maximize	0.25	Factor R in USLE. Indicates the effect of raindrop impact and rate of runoff associated with rain of moderately sized storms with occasional large storms	No events per year, erosive rain Intensity (USER)
On-pixel source:	Erodibility factor	Maximize	0.25	Factor K in USLE. Reflects soil profile reaction to hydrologic processes (e.g. raindrop impact, surface flow, roughness (topographic or induced), and rain water infiltration).	Soil structure; soil permeability, organic matter, %Silt , %Very fine sand, %Clay (USER)
On-pixel source:	Soil depth	Maximize	0.25		(USER)
On-pixel retention	Sediment retention	Minimize except for transition keep native vegetation (Maximize)	0.5	Reflects the efficacy of a pixel trapping sediment and holding it	From literature review. Factor affected by land cover type and management, geomorphology, climate. (USER)
On-pixel retention	Riparian continuity	Maximize	0.5	Indicated the continuity riparian areas	DEM and land use map (RIOS)
	Beneficiaries	Maximize	1	Indicate priority areas based on the number of beneficiaries of the ES (no people) or by the amount of the service (energy produced)	(USER)

InVEST models soil retention using the Universal Soil Loss Equation - USLE (Wischmeier & Smith 1978). The USLE is an empirical but robust model that combines the effect of the characteristics of the

soil (K factor), the intensity of the precipitation (R factor), conservation practices (P factor), slope steepness (S factor), slope length (L factor) and cover management (C factor) (Wischmeier & Smith 1978). The empirical equation has important limitations (Sharp et al., 2013; Estrada-Carmona et al., in review); however, it has shown to be applicable across a wide range of conditions to indicate areas of greater risk to soil erosion by water (Gaffer et al., 2008).

We parameterized the USLE using available data for the area. The K values were obtained from FAO surveys at a national level and soil type classification at a scale of 1:200,000 (FAO, 1989). The R factor was estimated using the total storm energy (E) and a maximum 30 minute intensity (I30) for each erosive storm (i.e. storms with total accumulated rainfall greater than 13 mm and separated by at least six hours) for 148 station years of measurements in 54 meteorological stations of the Costa Rican Institute of Electricity– (ICE; Gómez-Delgado, 2002). InVEST estimates the L and S factors using Desmet and Govers (1996) methodology for the watershed's digital elevation model with a 28.5 m resolution (Imbach, 2006). Land uses were defined by a 1996 LandSat image classification (Pedroni, 2003), the most accurate land use classification with the best spatial and thematic resolutions for our analysis to our knowledge. The C factor and the crop soil retention values for each the current land use were obtained from RIOS's extensive literature review (Vogl et al., 2013). The P factor was assumed to be 1.0 for current conditions since no detailed information about the support practices in the watersheds exists. But, we incorporated the effectiveness of the ideal cropping systems retaining soil by modifying the practices factor (P factor). The P factor was estimated as one minus the soil retention efficacy for each cropping system.

The USLE is better at estimating long term average erosion and it only estimates erosion by water (sheet and rill) (Wischmeier & Smith 1978). Therefore, other erosive processes such as bank erosion, landslides or even other types of erosion such as wind erosion are not considered (Wischmeier & Smith 1978). This is particularly true in the Cachi drainage area where there is a greater frequency of

landslides within the basin (Ramírez et al., 2008). Yet, this source of sediment is not directly related to land use decisions (afforestation is unlikely to stop land sliding) and should be considered background variability. A potential larger unquantified land use impact is the construction of unpaved roads (Gómez-Delgado et al., 2011).

We calculated the sediment delivery ratio, the proportion of the gross sediment exported per each pixel that actually reaches the reservoirs, to assess the accuracy of the USLE estimations. The delivery ratio was estimated as the ratio between the measured sediment yield in each reservoir (Table 4) and the gross sediment for each dam's drainage area (Bhattarai & Dutta, 2006). Our estimated average sediment per hectare was calculated as the total gross sediment exported per pixels divided by the drainage area multiplied by the sediment delivery ratio.

3.4. Targeting strategies

Defining priority areas to target efforts can be based using different criteria. For this reason, we tested the effectiveness of implementing cropping systems using three targeting strategies: RIOS default optimization (named RIOS), RIOS constrained to areas in conflict with current legislation (named RIOS&Legislation) and RIOS constrained to areas with erosive crops or crops on steep lands (named RIOS&C-S). RIOS optimization uses the pre-determined critical factors (Table 5) to find the most cost-effective areas to implement ideal cropping systems as we discussed in section 2.3. However, we also tested if enforcing current land use capability legislation is the most effective strategy or if using verifiable criteria's in field and key drivers of soil erosion is the most effective.

We determined the targeting strategy RIOS&Legislation by overlapping the land use capability developed for the Reventazon management plan (PREVDA, 2008) with the land use from 1996 (Pedroni, 2003). Costa Rica established in 1994 the land use capability for the national territory according to local conditions such as soil nutrients, soil depth, relieve, rockiness, floodable (Act N°

23214-MAG-MIRENEM, 1994). The land use capability classifies the land into eight categories, from null restrictions for productive activities (i.e. class I) to high restrictions (i.e. class VIII). We defined conflict areas as those areas that corresponds to 1) any productive activity occurring in areas that should be dedicated to forest protection (i.e. classes VII, VIII), 2) other agricultural activities than perennial crops in areas with severe limitations (i.e. class VI) and 3) other agricultural activities than semi-perennial and perennial crops occurring in areas with strong limitations (i.e. classes IV). We constrained RIOS to run and prioritize using only the areas in conflict (33,693 ha, ~41% of the upper Reventazon watershed area).

We determined the targeting strategy RIOS&C-S by overlapping the land use map and the slope. Estrada-Carmona et al., (in review), identified for the same watershed using a global sensitivity analysis, that the interaction between cover management and slope steepness is what mainly drives soil erosion in the region. Therefore, we used Estrada-Carmona et al. (in review) results and identify those areas located on 1) steep areas (steepness >23%) with productive uses (C factor > 0.07) and 2) erosive crops (C factor >0.4) on level landscapes (steepness <23%). We constrained RIOS to run and prioritize using only the areas where C and S factors interacts generating greater soil loss in the upper Reventazon watershed area (36,009 ha, ~44%).

3.5. Budget allocation

We assessed the changes on the provision of the ecosystem service soil retention across different budget levels. Low budget allocations correspond to the amount ($0.3 million USD) the Reventazon watershed plan assigned to invest on soil loss control and to implement agroforestry systems during 2008-2010 (PREVDA, 2008). The medium budget allocations correspond to the lowest and larger reported yearly dredging cost for both, Angostura and Cachi reservoirs. The national hydropower company, ICE, spent between $2-4 million dredging the dams (Vignola et al., 2012, Vignola et al., 2010). These costs exclude the financial support the ICE contributed to the Reventazon management

plan (PREVDA, 2008). Finally, the largest budget corresponds to the maximum amount ($7million) that would be needed to allocate to cover the maximum extent of agricultural land available for ideal cropping systems. We assumed an adoption rate of 100% during the first five years of implementing and maintaining ideal cropping systems.

We assumed that at least a five year of continuous budget allocation would be needed for two reasons. First, this period is approximately what it will take to fully establish ideal cropping systems (maximum soil retention) and to potentially increase yield production (Alegre, & Rat, 1996). Second, FONAFIFO distributes the payments for agroforestry in a five-year period (FONAFIFO, 2014).

We estimated the avoided cost as the cost of dredging the retained soil by each targeting strategy at the different budget allocations for the life span of the dams. Then we compared both, the cost of implementing ideal cropping systems (budget allocation) and the avoided cots. The cost of dredging one ton of sediment in the area is $1.3t-1 according to Vignola et al. (2010), who reported that ICE dredges every year 1.5millions·tonnes of sediment from the reservoirs (Angostura and Cachi) with a cost of at least $2 million USD. Approximately 70% of the sediment yield in the reservoirs is removed during the dredging. For instance, the life span of the dams was estimated as the sum of the accumulated sediment (30% of the sediment yield) through time until the reservoir capacity was full. The total retained soil is the cumulative throughout the life span of the dams. The avoided cost is estimated then as the dredging cost multiplied by the extended life span of the dam and the total retained soil up-stream due to the implementation of the ideal cropping systems. We excluded the first five years after of implementation to account for the time it will take to the practices to fully establish. The avoided cost is estimated only for Cachi and Angostura’s dams. Birris was incorporated into the Angostura drainage area in this analysis since we lacked information about the volume of the reservoir (Table 4.). We assumed constant conditions (i.e. sediment yield in the reservoirs, land cover) through time to estimate the avoided cost and the extension of the life span of the dams since we lack of

historical data for all the dams. Measurements in Angostura indicates a high yearly variability with reported extremely high sediment yields in the reservoirs up to five times greater than the average yields (Jiménez-Ramírez et al., 2004).

4. Results

Modeling results indicated a wide range of ES provisioning rates across targeting and budget allocation. InVEST (particularly the USLE) accuracy assessment indicated that model predictions are consistent with reported values for the study area. Our comparisons across targeting strategies and budget allocations indicated that the most cost-effective (highest soil retention per dollar) strategy is to target lands with erosive crops and crops on steep lands (RIOS&C-S) using medium budgets ($10-16.4million). Low budget allocations ($1.5million) yielded similar results across targeting strategies. And, the benefits of investing on ideal cropping systems exceeded the dredging cost using RIOS&C-S targeting strategy across budgets, given our modeling assumptions.

4.1. Universal Soil Loss Equation accuracy assessment

The soil retention ES provision rate was estimated as the relative change between current condition and each targeting strategy across the three budgets (Figure 17 and 18). We used this rate to estimate the reduction in sediment yield reaching the reservoirs and its effect extending the life span of the dams (Table 6), rather than the gross estimates of cumulative sediment. As a simple accuracy assessment of the gross estimates we compared our estimated average sediment per hectare with reported values. The estimated average sediment per hectare for the Birris and Angostura dams correspond to the values reported in other studies. The USLE underestimated measured values for the Cachi drainage area in which the frequency of landslides is higher (Table 4).

Figure 17. Covered area and retained soil by the implemented ideal cropping systems in each drainage area (Angostura, Cachi and Birris) under three targeting strategies (RIOS, RIOS constrained to areas in conflict with legislation and RIOS constrained to areas with erosive crops on steep slopes) and at different budget levels. The percentage of the cover area corresponds to the total area of each one of the drainage area of each dam.

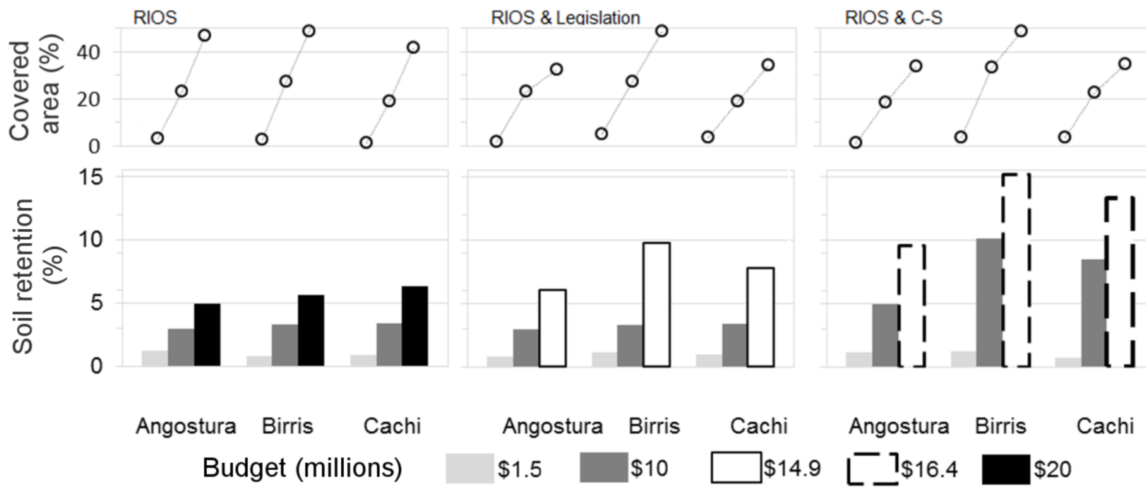


Figure 18. Covered area and retained soil in the upper and middle part of the Reventazon watershed by using three strategies to target ideal cropping systems (RIOS, RIOS constrained to areas in conflict with legislation and RIOS constrained to areas with erosive crops on steep slopes) at different budget levels. One-hundred percent of the area refers to the 73,441ha in the watershed where ideal cropping systems can be implemented.

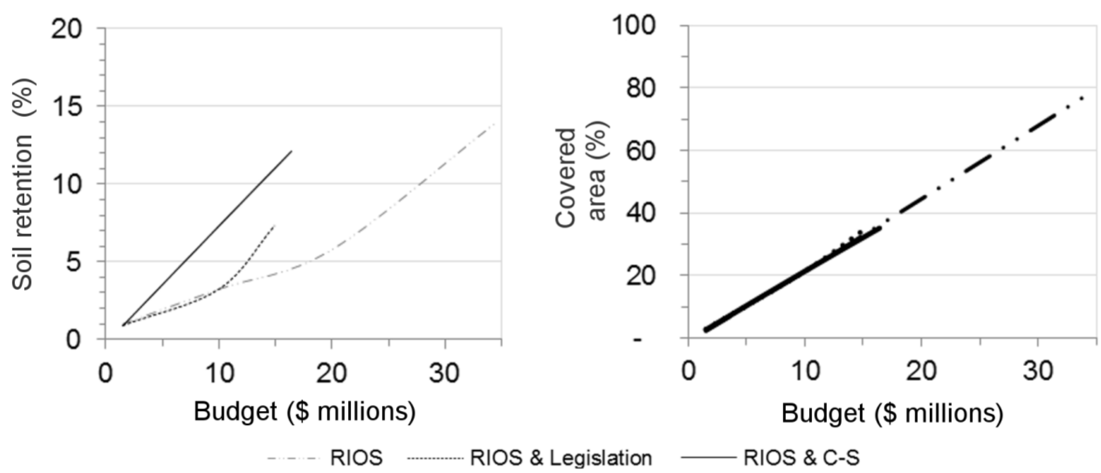


Table 6. Dams lifespan extension and avoided cost if ideal cropping systems (ICS) are implemented using different targeting strategies at different budgets levels.

	Implementation cost ($millions)		Life span (y)		Sediment yield (millions·t·y^{-1})		Up-stream retention (millions·t·y^{-1})	Total retained (millions·t)	Avoided cost ($millions)
Targeting strategies	Budget	Dam	No ICS	ICS	No ICS	ICS	ICS	ICS	ICS
RIOS&Legislation	1.5	Angostura	24	24	1.5	1.49	0.01	0.3	0.4
	1.5	Cachi	145	147	1.1	1.09	0.01	1.2	1.6
Total									1.9
RIOS&C-S	1.5	Angostura	24	24	1.5	1.49	0.01	0.2	0.3
	1.5	Cachi	145	147	1.1	1.09	0.01	1.8	2.3
Total									2.6
RIOS	1.5	Angostura	24	24	1.5	1.49	0.01	0.3	0.3
	1.5	Cachi	145	147	1.1	1.09	0.01	1.9	2.6
Total									2.9
RIOS&Legislation	10	Angostura	24	25	1.5	1.45	0.05	1.0	1.3
	10	Cachi	145	150	1.1	1.07	0.03	4.7	6.3
Total									7.6
RIOS&C-S	10	Angostura	24	26	1.5	1.37	0.13	2.7	3.6
	10	Cachi	145	153	1.1	1.05	0.05	8.1	10.8
Total									14.4
RIOS	10	Angostura	24	25	1.5	1.45	0.05	1.0	1.3
	10	Cachi	145	150	1.1	1.07	0.03	4.7	6.3
Total									7.6
RIOS&Legislation	14.9	Angostura	24	25	1.5	1.41	0.09	1.8	2.4
	14.9	Cachi	145	155	1.1	1.03	0.07	9.9	13.2
Total									15.7
RIOS&C-S	16.4	Angostura	24	26	1.5	1.36	0.14	3.0	4.1
	16.4	Cachi	145	161	1.1	1.00	0.10	16.3	21.8
Total									25.9
RIOS	20	Angostura	24	25	1.5	1.43	0.07	1.5	2.0
	20	Cachi	145	153	1.1	1.05	0.05	8.0	10.7
Total									12.7
RIOS	34.5	Angostura	24	27	1.5	1.34	0.16	3.5	4.7
	34.5	Cachi	145	163	1.1	0.98	0.12	18.8	25.0
Total									29.7

4.2. Targeting strategies and budget allocation comparison

The Birris dam has smallest drainage area yet has the highest erosion rates (Figure 15). This basin occupies only 3% of the upper and middle Reventazon, still both targeting strategies RIOS&C-S and RIOS&Legislation covered more area in this basin with ideal cropping systems yielding slightly higher soil retention rates, particularly at the higher budget levels (Figure 17). Cachi and Angostura's dams have the largest drainage area, occupying 55% and percent 42% of the Reventazon watershed, respectively. In these two dams, both targeting strategies RIOS and RIOS&Legislation tended to cover the same proportion of area at the medium budgets yielding similar soil retention rates. Modeling results show similar soil retention rates across targeting strategies with the lowest budget allocation

(Figure 17). Finally, RIOS&C-S yielded the highest soil retention rates across dams when medium and larger budgets were available (Figure 17 and 18).

The targeting strategy with RIOS and the maximum budget ($34.5million) yielded the maximum soil retention rate (14%). However, the targeting strategy RIOS&C-S yielded similar results (12%) using half of the budget ($16.4millions) and covering half of the area (Figure 18). The RIOS & Legislation targeting strategy is only more effective than RIOS when larger budgets were available (Figure 18). With low budgets ($1.5millions), all the different targeting strategies had low effectiveness since they only reduced ~1% of the total exported sediment and changed less than 3% of the area. The targeting strategies of RIOS & C-S and RIOS & Legislation used partially the $20millions budgeted ($16.4millions and $14.9millions, respectively), indicating that the most effective areas retaining soil can be covered with lower budgets (Figure 18).

The slope of both the covered area and the soil retention at different budgets indicates a marginal benefit (Figure 18). Modeling results indicates that on average, every million invested may cover with ideal cropping systems 2.3% (1,689 ha) of the agricultural land; however, every extra million invested will only reduce exported soil in a magnitude of 0.4, 0.5 and 0.8 percent using RIOS, RIOS & Legislation and RIOS & C-S targeting strategies, respectively. The marginal benefit across budgets was constant for RIOS & C-S, but it increased for RIOS (from 0.3 to 0.6) and RIOS & Legislation (from 0.3 to 0.8) when budget was increased from $10 to $20 million (Figure 18).

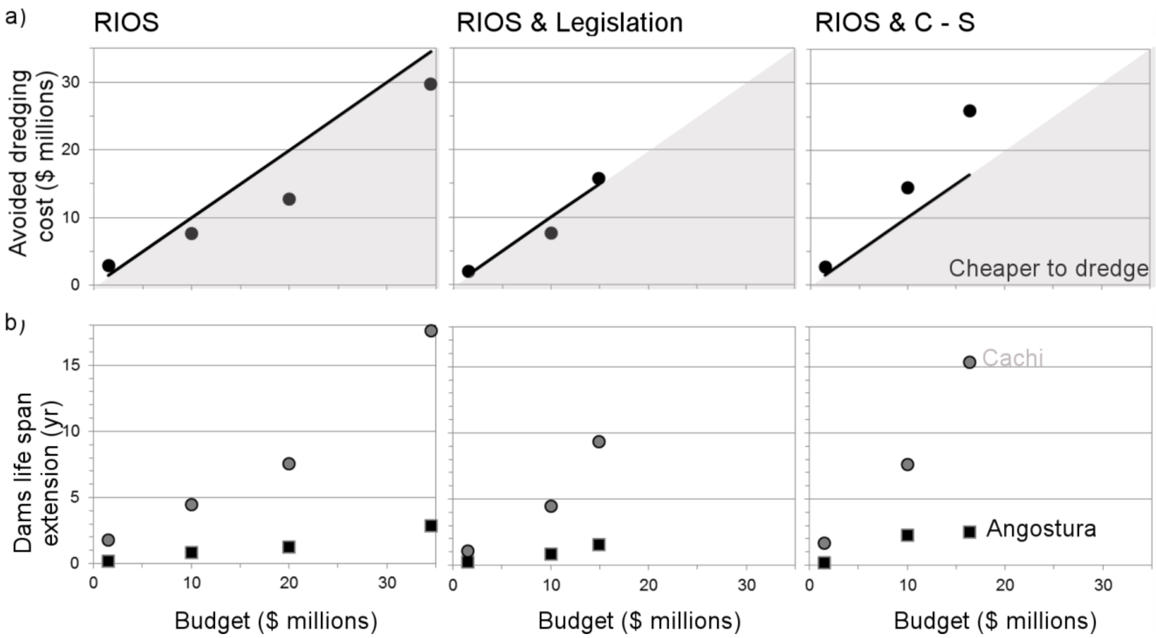
Budget allocation across cropping systems (i.e. annual, perennial, semi-perennial, pasture or reforestation) was consistent with the current land use distribution. The largest proportion of the budget (approximately 75%) across targeting strategies and budgets was designated to support perennial and pasture ideal cropping systems. Bare soil, although occupying low proportion in the watershed (1.2% of the area), was the third most invested activity across targeting strategies and

budgets, despite the highest implementation and maintenance cost (Supplemental Material II). This means that investing on bare soil is effective in comparison to other activities.

4.3. Benefit of implementing soil conservation practices (avoided cost)

Avoided cost is the cost the hydropower companies would have to spend dredging if the retained soil by the cropping systems entered the reservoir. Here, we assumed a constant sediment yield through the life span of each dam. We also assumed a constant soil retention rate through time after five years of cropping system establishment (Table 6). The estimated rates indicated that the targeting strategy RIOS & C-S is the only strategy that consistently retained enough soil up-stream across budgets allocations to make the investment on cropping systems cheaper than to remove the sediment from the reservoirs (Figure 19a). The targeting strategy RIOS & C-S also extended the dams' life span close to the maximum that could extended with RIOS and the highest budget ($34.5), which covers 78% of the watershed area where ideal cropping systems can be implemented (Figure 18). RIOS targeting strategy with a budget of $34.5millions extended the life span of the Angostura and Cachi dams, 2.9 years and 17.6 years, respectively. RIOS&C-S targeting strategy and with half of the budget ($16.5millions) extended both dams life span, 2.5 years and 15.3 years, respectively (Figure 19b).

Figure 19. Panel a) shows the avoided cost by the hydropower companies estimated as the cost of removing the sediment retained up-stream by the cropping systems (black dots) at the different budget levels and targeting strategies. The black line represents the implementation cost of the cropping systems, below this line (gray area), the implementation and maintenance cost of the ideal cropping systems is more expensive than the dredging cost of the retained soil by the ideal cropping systems. Panel b) shows the extension of the dams' life span across targeting strategies and budgets.



Other targeting strategies avoided costs was similar or lower than the implementation cost of the ideal cropping systems, potentially due to a low soil retention rate (Table 7). Still, almost all targeting strategies extended the life span of the dams between 0.8y and 1.5y for Angostura's dam and between 4.5y and 9.3y for Cachi's dam with budgets greater than $1.5millions (Figure 19b and Table 7). Comparing the total retained soil accumulated up-stream by the ideal cropping systems with the reported sediment yield in each reservoir offered a non-monetary assessment of the benefits. We found that targeting strategies RIOS&C-S (budgets $10 and $16.4 million) and RIOS (budget $34.5 million) retained up-stream during the whole dam's life span, the equivalent to two years of the current sediment yield in Angostura's dam (1.5millions·t·y·r-1, Table 4 and 7). The same targeting strategies

retained up-stream what is the equivalent amount to 7, 15 and 17 years, respectively, of the annual sediment yield (1.1millions·t·y·r-1, Table 4) in Cachi's dam.

5. Discussion

Our application of InVEST and RIOS tools to assess the provisioning of the soil retention ES is an initial attempt to better assess the role of agroecosystems as ES providers in Costa Rica. Our results indicate that targeting efforts to implement ideal cropping systems (combination of at least two or three soil conservation practices) on erosive crops or crops on steep slopes will likely provide the highest cost-effectiveness investment scenario, or in other words, the highest soil retention per dollar spent. Under this particular targeting strategy, investments in ideal cropping systems may be more cost effective than dredging sediment from the downstream reservoirs, given our modeling assumptions.

5.1. Role of agroecosystems as ES providers

The Costa Rican PES scheme is becoming more supported by local ES consumers such as hydropower companies, industry, tourisms among others (Pagiola et al., 2008; Blackman & Woodward, 2010). These consumers may demand a higher provision of ES at this local scale such as water quality. Improving water quality will require the provision of ES not only from the forested areas or spread trees but also from a proper agroecosystem management and planning.

ICE previous efforts in the upper-middle Reventazon watershed such as raising awareness, trainings, nurseries to foment agroforestry and technological transfer (i.e. vermicomposting or biodigestors) improved in agricultural lands the management of natural resources (Sims & Sinclair, 2008). Still, the benefits of those efforts in terms of the reduction of sediment loads and pollution in the reservoirs are marginal (PREVEDA, 2008). Marginal benefits on reducing sediment yield may be due to a poor monitoring strategy of the on-site and off-site effects of the efforts, to a spatiotemporal lag (e.g. Fremier et al., 2013) or to a low budget allocation. Low budget allocation ($1.5 million) in our

analysis indicates low rate of ES provisioning (less than 2% increase on soil reduction) regardless the targeting strategy. Yet, these investments might be profitable by the hydropower company as they not only reduce soil transport into the reservoir, but also for public relations. When considering higher investments, the amount of soil retained by investments in ideal cropping systems using the RIOS&C-S method might be enough to make investments more cost effective than remediating the effects of dredging (e.g. implementation and maintenance cost $16.4millions versus estimated dredging cots $23.3millions; Figure 4). Investments in soil conservation practices might also extend dam life span, which is one of the most critical concerns of hydropower companies with high sedimentation rates (Haun et al., 2013).

5.2. Targeting strategies

The majority of ES are spatially explicit as well as the pressure or threats (e.g. deforestation, soil erosion) to ecosystems and the services they provide. Targeting efforts, incentive or policy based, rather than "first-come first-served" guarantees the additionality and efficiency of the efforts (Robalino & Pfaff, 2013; Pfaff & Robalino, 2012; Wünscher et al., 2008). The Costa Rican PES scheme prioritizes PES for agroforestry systems based on land use capability (FONAFIFO, 2014), similarly to our RIOS&Legislation targeting strategy yet less aggressive at targeting erosive lands. However, our results indicate that targeting efforts to increase the provision of the ES soil retention on erosive crops and crops on steep slopes (> 23%) (RIOS&C-S) potentially will yield the highest benefits per dollar invested. Particularly, with the medium and larger budgets we tested for this targeting strategy ($10 or $16.4 million). Another advantage of the RIOS&C-S targeting strategy is that both, the slope steepness and cover management factors, are verifiable on the field. Using verifiable factors on the field to determine participation criteria in the PES scheme may add a sense of fairness to the program (Vignola et al., 2010) and decrease negative behavioral spillovers (Alpízar et al., 2013) such as reducing current voluntary implementation of conservation practices or reducing aversion to participate.

We tested three targeting strategies using an empirically based approach, USLE, to quantify the provisioning of the soil retention ES. Our modeling strategy, offers a simple but robust and conservative first approximation to a methodology that can be adapted and modeled iteratively to assess the potential contribution that changes in agroecosystems management has on providing ES. This first approximation also contributes to move beyond the assumption that spread trees will provide the demanded hydrological services by local consumers and contributes to improve spatial planning, one of the weaknesses of the Costa Rican PES scheme (Robalino & Pfaff, 2013). Also, this modeling exercise offers an opportunity to quantify the approximate benefits of investing on provisioning ES and, particularly private sector, may get more engage with more clear and direct benefits (Ruckelshaus et al., 2012). Higher engagement of the private sector in conservation is currently an important challenge in agricultural landscape planning across Latin America and the Caribbean (Estrada-Carmona et al., 2014). Future efforts with more complete available data may include more comprehensive hydrological and calibrated models to assess hydrological services (e.g. Gómez-Delgado et al., 2011).

6. Conclusion

Our results indicate that the cost of implementing ideal cropping systems (combination of at least two or three soil conservation practices) is potentially similar or cheaper than dredging. Particularly, we estimated that the highest soil retention per dollar spent is obtained by targeting efforts on erosive crops (C factor >0.4) or crops (C factor > 0.07) on steep lands (>23%) using medium budget allocations such as ~$10-20 millions. Low budget allocations yielded marginal benefits providing an increase of soil retention ES lower than 3%. However, all targeting strategies extended the life span of the dams by reducing sediment yields in the reservoirs, given our modeling assumptions. Our estimation of the provisioning of the soil retention ES due to changes in agroecosystem management is an empirical-based and conservative methodology that can be adapted and modeled iteratively to improve PES spatial planning in agroecosystems. Our methodology may also improve private or

industry sector long-term and strong engagement with more clear and direct benefits of their investments. Future research should incorporate transaction cost and explore other strategies to boost the voluntary implementation of ideal cropping systems through training, experimental farms or farmer scientist.

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APPENDIX A

Internet Search Terms (in English, Spanish and Portuguese)

Terms (English)
1. Agrobiodiversity
2. Agroecology
3. Agroforestry
4. Biological corridor
5. Buffer zone
6. Community-based forest management
7. Community-based natural resource management
8. Conservation agriculture
9. Food security and conservation
10. Initiative
11. Integrated landscape management
12. Integrated management
13. Integrated watershed management
14. Landscape initiative
15. Landscape management
16. Landscapes and livelihoods
17. Livelihoods
18. Multi-stakeholder
19. Natural resource management
20. Participatory
21. Program
22. Project
23. Socio-ecological
24. Territorial development
25. Territorial management
26. Territory

Plus names of each of the countries in Latin America and the Caribbean (23 Countries).

APPENDIX B

Survey to assess Integrated Landscape Management for agriculture, rural Livelihoods, and ecosystem conservation in Latin America and The Caribbean.

Continental Review Survey (LPFN)- English

1. Welcome!

Dear colleague,

Thank you for responding to this survey. By sharing your experiences, you will be contributing to a global effort to document and share lessons learned from landscape-scale initiatives to support food production, ecosystem conservation, and human wellbeing in rural landscapes ("ecoagriculture" initiatives). These results, in turn, will contribute to a strategic, international action and advocacy program to expand the use of sustainable landscape management approaches around the world. For more information on this program, please visit http://landscapes.ecoagriculture.org.

This questionnaire includes 7 pages, and should take about 20 minutes to complete. The survey asks questions about a landscape initiative in which you have been involved, and about the landscape where this initiative is located. A landscape initiative is defined as a multi-stakeholder project, program, or community-led effort to increase food production, ecosystem conservation, and rural livelihoods through integrated planning, decision-making, and management at a landscape scale. Landscape initiatives can include community-led efforts, government projects or programs, or initiatives supported by organizations from outside the landscape.

In appreciation of your contribution, you will receive an electronic copy of the final review study, highlighting key lessons learned, resources, and opportunities for supporting and expanding ecoagriculture initiatives. We will send this document to the e-mail address that you provide us in your survey response. Also, upon completion of the full questionnaire, you will be automatically entered to win one of three Apple iPad computers, which will be awarded to three randomly-selected respondents.

If you have any questions about the survey, please contact Abby Hart at ahart@ecoagriculture.org. Thank you very much for your valuable contribution to this research and to supporting the sharing of knowledge about sustainable landscape management!

Sincerely,
The Ecoagriculture Global Review Team

Continental Review Survey (LPFN)- English

2. Part 1: Respondent Information

Please provide the following basic information about yourself and your role in the landscape or landscape initiative.

Title:

First name:

Middle name:

Last name:

Email address:

What is the name of your organization?

Telephone number (please include any country or regional codes)

What is your position or title within the organization?

What is your role in the landscape or landscape initiative? (please describe)

Continental Review Survey (LPFN)- English

3. Part 2: Basic information on the landscape

Please describe the landscape where you were involved in promoting integrated activities to benefit food production, ecosystem conservation, and rural livelihoods.

On which continent is the initiative located?

Where is the landscape located? (please fill in as many as relevant)

Country:

State, province or region:

Locality (please list the districts, municipalities or towns within the landscape):

If the landscape has a name, please provide it here:

Approximately how large is the landscape (area)? (please answer in hectares or in square kilometers)

Hectares

Square kilometers

Do you know approximately how many people live in the landscape? (an estimate is OK)

☐ Yes: ☐ No:

How many people?

Continental Review Survey (LPFN)- English

Please provide a general characterization of land use/land cover in the landscape by checking the boxes that apply:

	Major landscape component (occupy more than 5% of the area)	Minor landscape component (present, but occupy less than 5% of the area)	Does not exist in the landscape
Tropical moist forest	○	○	○
Tropical dry forest	○	○	○
Temperate, upland, or montane forest	○	○	○
Grassland or savanna (without livestock)	○	○	○
Pasture (grassland for livestock)	○	○	○
Lakes and other water bodies	○	○	○
Annual grain crops	○	○	○
Other annual crops (horticulture, etc.)	○	○	○
Perennial crops in agroforestry systems (e.g., shade-grown cocoa or coffee)	○	○	○
Other sun-grown perennial crops (e.g., fruit orchards, coffee)	○	○	○
Wetland	○	○	○
Forestry plantations	○	○	○
Villages / towns / urban	○	○	○
Industry, mining, oil/gas development	○	○	○

Please list any other land use/land cover that is

a major landscape component (occupy more than 5% of the area) __________

a minor landscape component (occupy less than 5% of the area) __________

Continental Review Survey (LPFN)- English

4. Part 3: Basic information on the landscape initiative

Please tell us about the landscape initiative in which you have been involved.

In your responses, please describe the landscape initiative as it is currently organized and managed, even though it may have a longer history under previous organization and management.

Initiative name (or brief description):

Initiative dates:

Starting date (year only):

End date (year, if applicable):

State of the project (beginning, in process, ending, permanent):

Which organizations lead the initiative? (please provide the complete name of the organization if possible)

Please list key organization(s) within the landscape (e.g., farmers' associations, community or indigenous groups, local government, local NGOs):

Please list key organization(s) outside the landscape (e.g., donors, international organizations or NGOs):

Is this initiative a continuation of a previous project or effort?

☐ Yes ☐ No ☐ I do not know

If so, please provide the name of the previous effort:

Continental Review Survey (LPFN)- English

Which of the following issues were the main motivations for the landscape initiative? Indicate the level of importance of each issue that is trying to be improved with the landscape initiative.

	Very important	Important	Moderate important	No important	N/A
Enhance food security	○	○	○	○	○
Improve crop productivity	○	○	○	○	○
Diversify food production	○	○	○	○	○
Conserve biodiversity	○	○	○	○	○
Conserve soil or increase soil fertility	○	○	○	○	○
Stop or reverse natural resource degradation	○	○	○	○	○
Enhance sustainable land management	○	○	○	○	○
Reduce conflict among different resource users in the landscape	○	○	○	○	○
Increase farmer incomes	○	○	○	○	○
Improve livestock productivity	○	○	○	○	○
Improve health or nutrition	○	○	○	○	○
Conserve or increase water quality or water flow	○	○	○	○	○
Reduce the environmental impacts of agriculture	○	○	○	○	○
Mitigate climate change or obtain carbon credits	○	○	○	○	○
Reduce vulnerability to extreme weather events	○	○	○	○	○

There were other issues that motivated the establishment of the initiative? (Indicate the level of importance)

What percentage of the landscape has been directly affected by the initiative's activities, programs or policies?

☐ Yes: ☐ No:

What percentage (0-100%)?

Continental Review Survey (LPFN)- English

How many people has the initiative sought to benefit? (please provide either the number of people benefited or the percent of the landscape population benefited by the initiative)

☐ Number of beneficiaries: ☐ Percent of total landscape population: ☐ I do not know:

How many?

At the beginning of the initiative, was a baseline study, pre-project assessment, project document, or similar material prepared?

○ Yes: ○ No: ○ I don't know:

Does the initiative have cartographic information, aerial photographs or imagery of the landscape?

○ Yes ○ No ○ I don't know

If so, has this cartographic information been used for analysis and planning at landscape scale?

○ Yes: ○ No: ○ I am not sure:

Continental Review Survey (LPFN)- English

5. Part 4: Initiative activities and investments

Please tell us about the major activities, investments, or other changes that were included as part of the initiative.

Which of the following investments in agriculture were actively promoted by the landscape initiative?

	Was actively promoted	Was not actively promoted, but it occurred simultaneously in the landscape	Was not actively promoted and did not occurred in the landscape	N/A or Don't know
Promotion or introduction of new crops or crop varieties	◯	◯	◯	◯
Crop intensification with increased mechanization or application of fertilizers, pesticides, or herbicides	◯	◯	◯	◯
Crop intensification with agroecological methods (e.g., organic production, conservation agriculture, no-till, integrated pest management, improved fallows, etc.)	◯	◯	◯	◯
Livestock intensification with agroecological methods (e.g. improved grass and browse supply, management of water availability, etc.)	◯	◯	◯	◯
Establishment or improvement of irrigation systems	◯	◯	◯	◯
Adoption or expansion of agroforestry	◯	◯	◯	◯
Programs to adopt or improve home gardens	◯	◯	◯	◯
Implementation of laws or incentives to reduce the environmental impacts of agriculture	◯	◯	◯	◯
Implementation of soil conservation practices	◯	◯	◯	◯
Extension or capacity building programs to support agriculture	◯	◯	◯	◯
Establishment of new supply chain or marketing channels (including value addition and certification) for agricultural products	◯	◯	◯	◯
Promotion of native food species and agrobiodiversity	◯	◯	◯	◯

Other investment in agriculture (please specify)

Continental Review Survey (LPFN)- English

Which of the following investments in forestry, conservation, and natural resource management were actively promoted by the landscape initiative?

	Was actively promoted	Was not actively promoted, but it occurred simultaneously in the landscape	Was not actively promoted and did not occurred in the landscape	N/A or Don't know
New protected areas established	○	○	○	○
New management plans for existing protected areas	○	○	○	○
Other new reserves or community-based conservation areas (including areas that allow sustainable harvest and use of natural resources)	○	○	○	○
Other community-based natural resource management activities	○	○	○	○
Improved forestry management	○	○	○	○
Extension or capacity building programs to support forestry or natural resource management	○	○	○	○
Watershed management program or activities (e.g., restoration of riparian areas)	○	○	○	○

Other investment in forestry, conservation, or natural resource management (please specify)

Continental Review Survey (LPFN)- English

Which of the following investments in livelihoods and human wellbeing were actively promoted by the landscape initiative?

	Was actively promoted	Was not actively promoted, but it occurred simultaneously in the landscape	Was not actively promoted and did not occurred in the landscape	N/A or Don't know
Programs to reduce malnutrition and hunger	○	○	○	○
Programs for improving human health (e.g., improved access to health services)	○	○	○	○
Programs for improving gender equity	○	○	○	○
Programs to help secure land tenure and resource access rights	○	○	○	○
Preservation of traditional knowledge, values, or cultural resources	○	○	○	○
Programs to support enterprise development, savings and investment, or financial education	○	○	○	○
Activities to promote income generation and diversification outside of agriculture or forestry (e.g., handicrafts, ecotourism)	○	○	○	○
Efforts to reduce migration out of the landscape	○	○	○	○

Other investment in livelihoods and human wellbeing (please specify)

Continental Review Survey (LPFN)- English

Which of the following investments in multi-sectoral coordination and planning were actively promoted by the landscape initiative?

	Was actively promoted	Was not actively promoted, but it occurred simultaneously in the landscape	Was not actively promoted and did not occurred in the landscape	N/A or Don't know
Activities to strengthen existing coordination bodies (e.g., inter-jurisdictional councils, public-private partnerships)	○	○	○	○
Creation of new landscape coordinating bodies	○	○	○	○
Dialogue and mediation of conflicts among local communities or resource users	○	○	○	○
Dialogue and mediation of conflicts between local, national and international communities or resource users	○	○	○	○
Capacity building activities to help communities and stakeholders conduct integrated, landscape-scale management	○	○	○	○
Technical assistance to support integrated, landscape-scale management	○	○	○	○

Other investment in livelihoods and human wellbeing (please specify)

Please list any other activities or investments that were

actively promoted

not actively promoted, but it occurred simultaneously in the landscape

Continental Review Survey (LPFN)- English

6. Part 5: Stakeholders' roles in the initiative

Please tell us about the roles of different local and external groups in the initiative.

Which of the following types of groups have participated in designing or implementing the initiative? Please list only those groups that played a role in creating or carrying out the initiative or its component activities. Do not include groups that were merely informed or consulted about the initiative as affected stakeholders. Please check all that apply:

	Active participation designing the landscape initiative	Active participation implementing the landscape initiative	N/A
Local farmers' or producers' association	☐	☐	☐
Womens' association	☐	☐	☐
Indigenous group	☐	☐	☐
Group representing rural landless people	☐	☐	☐
Local government leaders (village leaders, mayors, chiefs, etc.)	☐	☐	☐
Government extension officers	☐	☐	☐
Other local or district government offices or staff	☐	☐	☐
State or provincial government offices or staff	☐	☐	☐
National ministries or national-level government staff	☐	☐	☐
Local non-governmental organization (NGO)	☐	☐	☐
Sub-national or national NGO	☐	☐	☐
International NGO	☐	☐	☐
Local or national university or research center	☐	☐	☐
Foreign or international university or research center	☐	☐	☐
In-country agribusiness (e.g., large plantation or ranch owners, agricultural land investors, etc.)	☐	☐	☐
Foreign agribusiness (e.g., large plantation or ranch owners, agricultural land investors, etc.)	☐	☐	☐
Logging/forest products industry	☐	☐	☐
Mining, oil, gas, or other industry	☐	☐	☐
Bi-lateral or multi-lateral donor(s)	☐	☐	☐
International organization focused on agriculture	☐	☐	☐

Continental Review Survey (LPFN)- English

International organization focused on conservation ☐ ☐ ☐

Other (please specify the name and if the organization is local, national or international)

Which sectors have been directly involved in the initiative? Direct involvement could include, for example, providing funding or staff resources, carrying out activities on the ground, or providing extension or capacity building services. Please check all that apply, but do not check sectors that were not directly involved in the initiative, even if they were conducting other activities in the landscape.

- ☐ Agriculture
- ☐ Livestock
- ☐ Forestry
- ☐ Natural resources, conservation, or environment
- ☐ Tourism
- ☐ Health
- ☐ Education
- ☐ Energy
- ☐ Roads, transportation, or infrastructure

Others (please specify)

Was any new institution or mechanism established to support the initiative?

○ Yes: ○ No: ○ I do not know:

If so, what type of institutions or mechanisms were established to support integrated landscape management?

- ☐ New cross-jurisdictional planning or governance entity (e.g., council of governments or territorial development group)
- ☐ Other organization that plays the role of supporting landscape-wide planning and coordination
- ☐ Mechanism or process to coordinate plans and investments proposed by different sectors (e.g., agriculture, forestry, infrastructure, irrigation)
- ☐ Mechanism or platform to allow different groups of land and resource users to resolve conflict

Other institutions or mechanisms? (specify)

Continental Review Survey (LPFN)- English

7. Part 6: Initiative outcomes/results

Please tell us about the initiative's outcomes and results.

Does this initiative include a monitoring and evaluation component?

- Yes
- No

Does the initiative use an adaptive management approach? (Note: adaptive management an iterative process that involves monitoring the results and effectiveness of project activities, reflecting on lessons learned from this experience, and then adjusting strategies to respond to this new information or to changing conditions.)

- Yes
- No
- I am not sure

Which of the following outcomes or changes took place within the ten years following the start of the initiative? (If the initiative started less than ten years ago, please indicate changes since the start of the initiative.) For each change, please indicate if the change took place as a result of the initiative or not as a result of the initiative. Please check the most appropriate box for each line:

Effects on agriculture:

	This change took place as a result of the initiative	This change took place, but not as a result of the initiative	This change did not take place	I am not sure if this change took place, or it is too early to tell
Agricultural yield per unit of land area (e.g., tons per hectare) increased	○	○	○	○
Agriculture became more profitable	○	○	○	○
Total area under agriculture and pasture increased	○	○	○	○
Environmental impacts of agriculture were reduced	○	○	○	○
Agricultural biodiversity (agrobiodiversity) was protected or enhanced	○	○	○	○

Other benefit (please specify)

Continental Review Survey (LPFN)- English

Effects on conservation and ecosystem services

	This change took place as a result of the initiative	This change took place, but not as a result of the initiative	This change did not take place	I am not sure if this change took place, or it is too early to tell
Rare, threatened, or endangered species were better protected	○	○	○	○
Overall biodiversity of the region was better protected	○	○	○	○
The amount or connectivity of natural habitats was increased	○	○	○	○
Water quality, quantity, or regularity improved	○	○	○	○
Ecosystem services that support agriculture (e.g., irrigation water supply, pollination, soil fertility) were restored or protected	○	○	○	○
Other ecosystems services (e.g., urban water supplies, flood control, carbon storage) were restored or protected	○	○	○	○

Other benefit (please specify)

Effects on livelihoods and the poor:

	This change took place as a result of the initiative	This change took place, but not as a result of the initiative	This change did not take place	I am not sure if this change took place, or it is too early to tell
Food security or nutrition for landscape inhabitants were improved	○	○	○	○
Household cash income for low-income residents was increased	○	○	○	○
Non-cash measures of livelihoods (e.g., greater material assets, cleaner or more reliable water, better educational resources) were improved	○	○	○	○
Communities became less vulnerable to shocks and disasters (e.g., landslides, floods, droughts, epidemics)	○	○	○	○
Access to health services improved	○	○	○	○

Other benefit (please specify)

Continental Review Survey (LPFN)- English

Effects on governance, institutions, and social capital:

	This change took place as a result of the initiative	This change took place, but not as a result of the initiative	This change did not take place	I am not sure if this change took place, or it is too early to tell
Local communities gained capacity to sustainably manage agriculture and natural resources	○	○	○	○
Local communities became more empowered to negotiate and participate in political decisions	○	○	○	○
Coordination and cooperation among stakeholders (e.g., local communities, district government, private sector, NGOs) improved	○	○	○	○
Coordination and cooperation among sectors (e.g., agriculture, environment, health) improved	○	○	○	○
Women gained power or capacity to improve their wellbeing	○	○	○	○
Traditional and local knowledge on agriculture and natural resources has been preserved and used	○	○	○	○

Other benefit (please specify)

What has been the most successful aspect of the initiative?

What has been the least successful aspect of the initiative?

Would you be willing to participate in a more in depth interview regarding your experiences with this landscape initiative?

○ Yes ○ No

Continental Review Survey (LPFN)- English

Do you know of any other ecoagriculture initiatives in Latin American that might be willing to share about their experiences?

Name of the initiative(s):

Country:

Region:

Contact person:

Telephone:

Email:

Help us improve our survey. Please leave your comments about the survey - Did you have any difficulty understanding the questions? Was the survey too long or difficult? Did you have any technical difficulties completing the survey? Thank you for your thoughtful comments!

Continental Review Survey (LPFN)- English

8. Thank you!

Thank you very much for completing this questionnaire! In appreciation of your contribution, we will send you an electronic copy of the final review study to the e-mail address that you provided. You have also been entered to win one of three Apple iPad computers, which will be awarded to three randomly-selected respondents.

For more information about the Landscapes for People, Food and Nature Initiative that is supporting this study, please visit http://landscapes.ecoagriculture.org.

APPENDIX C

Interview to assess Integrated Landscape Management for agriculture, rural Livelihoods, and ecosystem conservation in Latin America and The Caribbean

NOTAS SOBRE LA ENTREVISTA DEL TIER 2
LOGISTICA
Verifique que la conexión entre el skype y el callnote está activa. Este segura de comenzar la grabación antes de llamar.
Leer las respuestas del TIER 1 para estar un poco contextualizada con la iniciativa
Antes de llamar verifique cuáles pregunta le hará al entrevistado

ESTRUCTURA ENCUESTA
Las preguntas están divididas con base en los HECHOS o las INTERPRETACIONES, y con base en quién/cuántos entrevistados deben responder las preguntas. Estas clasificaciones tienen los siguientes significados:
HECHOS –básicamente preguntan sobre una información objetiva (basada en hechos) que debe ser verificable independientemente. Cualquier entrevistado(a) bien informado(a) debe proveer básicamente la misma respuesta para cuestiones basadas en HECHOS. Así, no es necesario preguntar cuestiones de HECHOS para todos(as) los(as) entrevistados(as).
INTERPRETATIVA – la pregunta incluye un elemento de subjetividad, interpretación y percepción personal. Inclusive donde existe una realidad objetiva (e.g., que tan efectiva ha sido una iniciativa con relación a indicadores variados), diferentes personas pueden tener percepciones distintas de esa realidad. Cuando estamos interesados en entender esas diferentes percepciones, es cuando hacemos las preguntas INTERPRETATIVAS.
SOLO 1 – la entrevistadora debe preguntar la pregunta a solamente un(a) entrevistado(a), él(la) cual se considera ser él(la) mayor conocedor(a) del asunto en cuestión. Las preguntas SOLO1 son basadas en HECHOS, y una vez que obtenemos la información necesaria, no hay necesidad de hacer la pregunta a otras personas.
TRIANGULAR – la entrevistadora debe hacer la pregunta a cuantos(as) entrevistados(as) crea necesario para establecer una respuesta <u>confiable</u>. Preguntas TRIANGULARES generalmente son preguntas basadas en HECHOS, en relación a las cuales es posible que algunos(as) entrevistados(as) no tengan la información completa o precisa y entonces nos podrían proveer una respuesta engañosa. La entrevistadora debe empezar haciendo la pregunta al primer entrevistado(a) que se considere conocedor del asunto. Si hay duda respecto a la confiabilidad de la respuesta, la entrevistadora debe continuar haciendo la pregunta a entrevistados(as) adicionales hasta que ella esté satisfecha y con información consistente y precisa.
PREGUNTE A TODOS(AS) – esas son generalmente preguntas INTERPRETATIVAS cuyo objetivo es comprender cómo distintos actores perciben la iniciativa y sus resultados. Tales cuestiones deben ser hechas a todos(as) los(as) entrevistados(as).

Objetivo: cerca de 15 preguntas; no más que 20
Tamaño de la muestra (# de paisajes): seleccionar 12-14 paisajes de alta prioridad que estamos seguros de incluir, además de 6-8 adicionales que intentaremos incluir si tenemos tiempo.
Intensidad de la muestra (# de entrevistados por paisaje): mínimo de 4, máximo de 6.
Entrevistados(as) deben representar distintos sectores, niveles y perspectivas. Debe haber al menos alguna representación del sector de conservación y del sector de agricultura. Entrevistados(as) deben incluir al menos una organización local, una representación rural o de comunidades, y, cuando aplique, un actor externo (donante, organización nacional o internacional, etc.) para cada iniciativa.
La mayoría, si no la totalidad, de los entrevistados(as) deben tener una perspectiva de todo el paisaje. No queremos respuestas que sean informadas solamente por el conocimiento del entrevistado(a) respecto a su finca o pueblo. Una posible excepción es cuando algunos actores ubicados en comunidades estén familiarizados principalmente con un área local, pero no con todo el paisaje. Esto está OK en la medida que sus perspectivas parezcan temáticamente anchas (i.e., consciente de las cuestiones de agricultura, medios de vida y conservación, además de las instituciones, políticas y estrategias relacionadas a ellas).

Presentación nuevo contacto en el TIER 2

Introducción: Actualmente Amigos de la Ecoagricultura en asocio con el CATIE estamos llevando a cabo una sistematización o búsqueda de experiencias de ecoagricultura en América Latina. La finalidad de este estudio es conocer y aprender sobre el contexto o bajo qué condiciones de dan este tipo de manejo de integral de paisajes. Nosotros definimos una iniciativa de ecoagricultura como aquella iniciativa que busca al mismo tiempo mejorar la producción agropecuaria, la conservación de los recursos naturales, la calidad y medio de vida de las comunidades y la gobernanza o empoderamiento de las comunidades sobre sus RN a una escala de paisaje.

Descripción proyecto: La primera etapa del proyecto consistió en contactar a las personas líderes o personas contacto de un conjunto de iniciativas, proyectos o programas que buscamos a través del internet. En el caso del [INICIATIVA] contactamos al Sr. / Sra. [NOMBRE CONTACTO], al cual le solicitamos su colaboración con el llenado de una encuesta. Después de analizar las encuetas que fueron diligenciadas, seleccionamos unas iniciativas las cuales estamos interesados en conocer más detalladamente. Para lograr esto queremos entrevistar a varios actores o líderes claves en el paisaje que han venido trabajando con la iniciativa [INICIATIVA] y tienen un buen conocimiento del paisaje. Lo estamos contactando porque [NOMBRE CONTACTO] nos indicó que usted nos podría colaborar.

La entrevista: La entrevista que le vamos a hacer, dura aproximadamente una hora. En esta entrevista le haremos preguntas sobre el paisaje donde se encuentra ubicada la iniciativa [INICIATIVA], sobre la iniciativa misma, la participación de diferentes actores o grupos en la iniciativa, las instituciones y la gestión de la iniciativa, políticas y gobernanza, y finalmente sobre las inversiones y los logros de la misma. No dude en interrumpirme o preguntarme si alguna pregunta o concepto no es claro. Algunas veces usamos terminología que es muy específica y que puede ser confusa, así que por favor no dude en preguntarme. De igual manera si no tiene conocimiento o información para responder alguna pregunta no hay ningún problema y solo pasamos a la siguiente pregunta.

Antes de comenzar me gustaría agradecerle de antemano por su tiempo y colaboración, y también me gustaría saber si tiene alguna duda o comentario.

Presentación contacto del TIER 1

De antemano le agradezco por su colaboración y participación, en días anteriores estuvimos revisando y analizando las diferentes encuestas que fueron llenadas por las diferentes iniciativas en América Latina, y seleccionamos la iniciativa [XXXX] para conocerla más detalladamente.

En esta segunda etapa de nuestra búsqueda de iniciativas ecoagrícolas, nos gustaría poder entrevistar a varios actores o líderes del paisaje que tiene buen conocimiento sobre la iniciativa y que ha estado involucrado con la iniciativa durante un buen tiempo. Lo ideal sería si me puede brindar los nombres y teléfonos de otras 5 o 6 personas que usted considera pueden participar en la entrevista y que han estado trabajando en los diferentes componentes como el agropecuario, conservación, calidad de vida de las comunidades, gobernanza, educación, etc. y/o que hace parte de organizaciones locales, gobiernos, ONG, universidades, etc. [ANOTAR CONTACTOS].

La entrevista:

La entrevista durará aproximadamente una hora y cubriremos temas similares a la encuesta que ya diligenció pero en más detalle. No dude en interrumpirme o preguntarme si alguna pregunta o concepto no es claro. Algunas veces usamos terminología que es muy específica y que puede ser confusa, así que por favor no dude en preguntarme. De igual manera si no tiene conocimiento o información para responder alguna pregunta no hay ningún problema y solo pasamos a la siguiente pregunta.

Antes de comenzar me gustaría agradecerle de antemano por su tiempo y colaboración, y también me gustaría saber si tiene alguna duda o comentario.

SECCION 1: INFORMACIÓN SOBRE LA PERSONA ENTREVISTADA

Por favor, provea la siguiente información básica sobre usted mismo y su papel en el paisaje y/o en la iniciativa de paisaje.

*Primer nombre:

Segundo nombre:

*Apellidos:

*Dirección correo electrónico:

*Nombre de su organización:

Teléfono (Por favor incluir el código del país - región):

*Su posición o cargo dentro de la organización:

¿Cuál es su papel en el paisaje o en la iniciativa de paisaje? (por favor describa):

SECCION 2: INFORMACIÓN SOBRE EL PAISAJE

POR FAVOR USE EL CUADRO PARA INGRESAR LA INFORMACIÓN ¿? 2.1, 2.11.
ESTE SEGURA QUE **INDICA LA IMPORTANCIA**. 1: más importante, 4: menos

En orden de importancia, cuáles son las cuatro sectores económicos (p.e. *agropecuario, forestal, pesquero, turismo, extracción, industria y otros*) más importantes en el paisaje?
(HECHOS/TRIANGULAR)

Si la agricultura es mencionada, por favor clasifique si es:

Sector		Pequeña escala			Mediana escala		Gran escala	
		Subsistencia	Comercial		Comercial		Comercial	
			Mercados locales / nacionales	Mercados internacionales / Exportación	Mercados locales / nacionales	Mercados internacionales / Exportación	Mercados locales / nacionales	Mercados internacionales / Exportación
Agropecuario								
Forestal								
Pesca								
Turismo								
Extracción								
Industria								
Otro:								
Otro:								

Es posible que varias de esas categorías agrícolas sean prioritarias

POR FAVOR USE EL CUADRO PARA INGRESAR LA INFORMACIÓN ¿? 2.2, 2.2.1.
ESTE SEGURA QUE **INDICA LA IMPORTANCIA**. 1: más importante, 4: menos importante

En orden de importancia, cuáles son los cultivos u otros productos agropecuarios / forestales más importantes en el paisaje?
(HECHOS / ¿? SOLO A 1)
Nota entrevistador: *Esto puede incluir cultivos, ganadería, fibras, cultivos para biocombustible, otros productos maderables y no maderables, etc.*
Se debe especificar el cultivo o el producto, *por ejemplo, maíz, banano, café, leche, puercos, teca o piscícolas.*
"Más importantes" *en términos de su contribución económica (para el caso de cultivos orientados a mercados) o contribución para suplir los mercados locales (para el caso de los cultivos de subsistencia)*

Cuál es el mercado principal o usos para cada uno de esos cinco cultivos o productos:
(HECHOS / ¿? SOLO A 1)

p.e cultivos (cuáles?), ganadería, fibras, cultivos para biocombustible, otros productos maderables y no maderables, etc.	Subsistencia	Mercados locales / nacionales	Mercados internacionales / Exportación
Prod1:			

Prod2:			
Prod3:			
Prod4:			
Prod5:			

Cuál es el tipo de tenencia de la tierra más común en el paisaje?
(HECHOS / ¿? SOLO A 3)
Nota entrevistador: *La meta es entender los principales tipos de propiedad y tenencia de la tierra en el paisaje.*

Ejemplos de las categorías de tenencia	**Solo las más importantes:** abarcan más del 10-20% del paisaje
a) tierras públicas o del estado	
b) tierras comunales	
c) propiedad privada manejada por los propietarios	
d) propiedad privada manejada por compañías	
e) propiedad privada aprovechada o manejada por arrendatarios	
Otro:	
Otro:	

Cómo considera usted que el paisaje donde se encuentra la iniciativa es definido o delimitado geográficamente?
(INTERPRETATIVA / ¿? TODOS) aclarar
Nota entrevistador: *De pronto es necesario hacer la misma pregunta de diferentes maneras para garantizar que el entrevistado la entienda. Básicamente queremos saber cómo el entrevistado ve la extensión geográfica del paisaje, y cómo ésta es delimitada. La pregunta **NO** pretende preguntar sobre el proceso de delineación del paisaje.*

Queremos saber si el entrevistado piensa que los límites corresponden a:	Si	No
Jurisdicciones (p.e. villas, municipalidades, cantones)		
Límite legal (p.e. áreas protegidas y sus zonas de amortiguamiento)		
Cuencas		
Río, lago, divisoria de aguas, u otro elemento geográfico mayor		
Ecosistema (p.e. un humedal grande)		
Rango de una o más especies de interés para la conservación		
Límite cultural o grupo étnico		
Un problema que debía ser resuelto		
Usaron otro criterio? Cuál?		
Otro:		
Otro:		

Los límites originales del paisaje han cambiado? Cómo y por qué?
(INTERPRETATIVA/ ¿? TODOS)

Hubo eventos (naturales, políticos, sociales, económicos, conflictos) que afectaron el paisaje y generaron cambios importantes en los últimos 25 años. Por favor, mencionar los más importantes.

(INTERPRETATIVA/ ¿? TODOS)
Nota entrevistador: *Esta debe ser una pregunta abierta. Queremos saber si hay un entendimiento común del paisaje y sus dinámicas. La pregunta también debe revelar algunos de los retos que la iniciativa pretende resolver. Si el entrevistado necesita o quiere ayuda para entender la pregunta, se pueden dar algunos ejemplos de cambios importantes, como los cambios mayores en el uso de la tierra o las actividades económicas (p.e. deforestación, nuevas plantaciones), conflictos/guerras, e importantes designaciones de tierras como áreas protegidas.*

SECCION 3: INFORMACIÓN SOBRE LA INICIATIVA
Cuáles fueron los retos principales o problemas que motivaron la creación de la iniciativa de paisaje?
(INTERPRETATIVA/ ¿? TODOS)
Nota entrevistador: *Hacer como pregunta abierta. Esperamos que en algunos casos habrá un reto o un problema principal, mientras que en otros casos habrán más. Queremos que el entrevistado identifique los retos/problemas **más importantes** - no una lista inservible. Si se ve que el entrevistado se esta desviando, hacerlo que mencione **máximo tres o cuatro** de los retos claves.*

1)
2)
3)
4)

Cuáles cree usted son los objetivos más importantes de la iniciativa?
(INTERPRETATIVA/ ¿? TODOS)
Nota entrevistador: *De nuevo, puede haber solo un objetivo o varios. Si el entrevistado piensa que hubo varios objetivos, déjelo listarlos y anótelos. Pero asegúrese al final que tiene claro **los tres o cuatro objetivos más importantes**, ya que se preguntará más adelante sobre la efectividad de la iniciativa en relación a esos objetivos.*

1)
2)
3)
4)

Cuáles fueron las 3 o 4 actividades o inversiones principales de la iniciativa?
(INTERPRETATIVA/ ¿? TODOS)
Nota entrevistador: *Queremos obtener dos cosas de esta pregunta.*
La primera, *es entender qué hizo la iniciativa y si esto incluyó un conjunto de actividades "balanceadas" para alcanzar los múltiples objetivos de la iniciativa. Por lo tanto, l**a pregunta debe ser abierta** para dejar que la persona mencione las 3 o 4 principales actividades, inversiones, o intervenciones, a pesar del sector u objetivo en la que esta caiga.*
Lo Segundo*, es entender si la iniciativa realmente incluyó actividades relacionadas a la agricultura (cultivos/ganado), conservación, medios de vidas rurales, y fortalecimiento institucional - inclusive si el entrevistado no identifica estas en las tres o cuatro actividades. Por lo tanto, si las tres o cuatro actividades no incluyen las actividades o inversiones relacionadas a las categorías, hacer la siguiente pregunta.*

1)
2)
3)
4)

La iniciativa incluyó alguna actividad relacionada con X?
(INTERPRETATIVA/ ¿? SI ES NECESARIO)
Nota entrevistador: *X puede ser agricultura (cultivos/ganado), conservación, medios de vidas rurales, y fortalecimiento institucional, si no fue mencionada en las tres o cuatro más importantes.*

Cuáles fueron las principales fuentes de financiamiento para las actividades o componentes?
(HECHOS / TRIANGULAR)
Nota entrevistador: *Esta pregunta debe ser hecha varias veces,* ***una para cada una de las tres o cuatro actividades*** *o inversiones que fueron mencionadas en la pregunta 3.3.*

Actividades mencionadas 3.3 y 3.3.1	*apoyo local en especie / directo (p.e. plantación árboles, terrazas hechas por los finqueros o grupos comunitarios, esfuerzos de los trabajadores de los gobiernos)*	*apoyo externo (p.e. donante o fondos del gobierno)*

<u>SECCION 4</u>: PARTICIPACIÓN EN LA INICIATIVA
Cuáles fueron los principales grupos involucrados en el **diseño** de la iniciativa? Cuál fue el papel de cada uno de estos grupos?
(INTERPRETATIVA/ ¿? TODOS)
Nota entrevistador: *Esta es una pregunta abierta.* ***Estamos interesados en ver si los entrevistados identifican los grupos locales y externos, y cuáles sectores son considerados <u>los más influyentes</u>.*** *Los grupos pueden ser. Los entrevistados puede que mencionen varios grupos de actores del paisaje, como grupos que no son actores del paisaje pero que están involucrados en el financiamiento/desarrollo/facilitación de la iniciativa.*

Grupos (p.e *organizaciones locales/comunitarias, gobiernos locales, gobiernos regionales/nacionales, sociedad civil, sector privado, donantes, organizaciones internacionales, academia u otros)*	Papel	Externo o local

Grupos (p.e *organizaciones locales/comunitarias, gobiernos locales, gobiernos regionales/nacionales, sociedad civil, sector privado, donantes, organizaciones internacionales, academia u otros)*	Papel	Externo o local

Se involucraron los grupos marginados del paisaje en el **diseño** de la iniciativa?
(INTERPRETATIVA/ ¿? TODOS SI NO SALIÖ EN LA PREGUNTA 4.1, sino obviar)
Nota entrevistador: *"Grupos marginalizados" puede incluir minorías étnicas, campesinos sin tierra y mujeres. De todas maneras, sin definir el término, le permitimos al entrevistado interpretar la pregunta basado en los grupos que él piensa son marginalizados dentro del paisaje.*

Se involucraron a los pequeños productores o las asociaciones de productores [nota entrevistador: incluir si aplica a los gestores forestales de pequeña escala] del paisaje en el **diseño** de la iniciativa?
(INTERPRETATIVA/ ¿? TODOS SINO SALIO EN LA PREGUNTA 4.1)

Se involucraron a los grandes productores o agronegocios [nota entrevistador: incluir si aplica a los gestores forestales de gran escala] del paisaje en el **diseño** de la iniciativa?
(INTERPRETATIVA/ ¿? TODOS SINO SALIO EN LA PREGUNTA 4.1)

Considera que se debió incluir algún grupo de actores en el **diseño** de la iniciativa y que no fue incluido? Cuáles grupos?
(INTERPRETATIVA/ ¿? TODOS)

Cuáles fueron los principales grupos involucrados en la **implementación** de la iniciativa? Cuál fue el papel de cada uno de estos grupos?
(INTERPRETATIVA/ ¿? TODOS)
Nota entrevistador: *Esta es una pregunta abierta.* ***Estamos interesados en ver si los entrevistados identifican los grupos locales y externos, y cuáles sectores son considerados los más influyentes.*** *Los entrevistados puede que mencionen varios grupos de actores del paisaje, como grupos que no son actores del paisaje pero que están involucrados en el financiamiento/desarrollo/facilitación de la iniciativa.*

Grupos (p.e *organizaciones locales/comunitarias, gobiernos locales, gobiernos*	Papel	Externo o local

regionales/nacionales, sociedad civil, sector privado, donantes, organizaciones internacionales, academia u otros)		

Se involucraron los grupos marginados del paisaje en la **implementación** de la iniciativa?
(INTERPRETATIVA/ ¿? TODOS SINO SALIO EN LA PREGUNTA 4.2)
Nota entrevistador: *s. Preguntar sin definir el término "marginado", le permitimos al entrevistado interpretar la pregunta basado en los grupos que él piensa son marginado dentro del paisaje. Si el entrevistado no entiende el concepto o se desvía, dar ejemplos: "Grupos marginados" puede incluir minorías étnicas, campesinos sin tierra y mujeres*

Se involucraron a los pequeños productores o las asociaciones de productores [nota entrevistador: incluir si aplica a los gestores forestales de pequeña escala] del paisaje en la **implementación** de la iniciativa?
(INTERPRETATIVA/ ¿? TODOS SINO SALIO EN LA PREGUNTA 4.2)

Se involucraron a los grandes productores o agronegocios [nota entrevistador: incluir si aplica a los gestores forestales de gran escala] del paisaje en la **implementación** de la iniciativa?
(INTERPRETATIVA/ ¿? TODOS SINO SALIO EN LA PREGUNTA 4.2)

Considera que se debió incluir algún grupo de actores en la **implementación** de la iniciativa y que no fue incluido? Cuáles grupos?
(INTERPRETATIVA/ ¿? TODOS)

<u>SECCION 5</u>: INSTITUCIONES Y GESTION DE LA INICIATIVA

Al comienzo de la iniciativa existían grupos en el paisaje que estaban liderando o facilitando actividades para apoyar el manejo integrado del paisaje (p.e. evaluaciones de paisaje, planeación, procesos multi-actores, etc)? Si fue así, cuáles fueron esos grupos y qué estaban haciendo?
(HECHOS/ TRIANGULACIÓN)

Grupos que existían	*<u>aspectos técnicos(</u> p.e. que tipo de información, datos, o análisis fueron usados para hacer la evaluación del paisaje)*	*<u>aspectos sobre el proceso</u> (p.e. cómo los grupos fueron ayudados para guiar o construir las decisiones sobre el manejo del paisaje, quién estuvo involucrado en el procesos de toma de decisiones, y si el proceso fue más tecnocrático o participativo)*

En el transcurso de la iniciativa se crearon nuevos grupos para liderar o facilitar las actividades del manejo integrado del paisaje?, o fueron grupos existentes que antes no cumplían estas funciones pero que después de la iniciativa tomaron este papel?. Si fue así, cuáles fueron esos grupos y qué hacen?
(HECHOS/ TRIANGULACIÓN)

Grupos creados	*<u>aspectos técnicos(</u> p.e. que tipo de información, datos, o análisis fueron usados para hacer la evaluación del paisaje)*	*<u>aspectos sobre el proceso</u> (p.e. cómo los grupos fueron ayudados para guiar o construir las decisiones sobre el manejo del paisaje, quién estuvo involucrado en el procesos de toma de decisiones, y si el proceso fue mas tecnocrático o participativo)*

Como son financiados los nuevos o existentes grupos? El financiamiento tiene un tiempo limitado o es contínuo?
(HECHOS/ TRIANGULACIÓN)

<u>SECCION 6</u>: POLÍTICAS Y GOBERNANZA

***<u>Nota entrevistador</u>*<u>:</u>** Provea una breve transición “Ahora, me gustaría preguntarle sobre el papel de las políticas apoyando o limitando el desarrollo de la iniciativa”.

Hubo algunas políticas públicas, leyes, o procedimientos que fueron especialmente útiles para apoyar e incentivar desarrollo de la iniciativa?

(INTERPRETATIVA/ TRIANGULACIÓN)
Nota entrevistador: *Acá estamos preguntando específicamente sobre las políticas que apoyaron el proceso integrado o participativo del manejo del paisaje. Por lo tanto, eso puede incluir políticas de descentralización, políticas que reconocen a las entidades locales como administradores de los recursos, procesos a nivel regional para la planeación de los usos de la tierra o desarrollo territorial, etc.* ***NO*** *estamos preguntado a los entrevistadores que identifiquen las políticas que tienen el propósito de incrementar la compatibilidad entre la agricultura y el ambiente, o apoyar paisajes multifuncionales como los pagos por servicios ambientales, leyes para la protección ambiental, etc.*

Hubo alguna política pública, ley o procedimiento que especialmente obstaculizó el desarrollo de la iniciativa?
(INTERPRETATIVA/ TRIANGULACIÓN)
Nota entrevistador: *Similar a la pregunta anterior, acá estamos preguntando específicamente sobre las políticas que inhibieron el proceso integrado o participativo del manejo del paisaje. Por lo tanto, esta puede incluir estructuras de gobierno que fallaron en devolver el poder a las autoridades locales o entidades administradoras de los recursos naturales. De nuevo,* ***NO e****stamos preguntando al entrevistado identificar las políticas relacionadas a la agricultura y el ambiente, p.e subsidios perversos a la agricultura.*

La iniciativa resultó en algún cambio importante en la política o gobernanza en relación a uso tierra, el manejo de los recursos naturales, o la regulación de actividades económicas? Si fue así, por favor describa según su percepción los cambios más importantes y explique como la iniciativa lo logró.
(HECHOS/ TRIANGULACIÓN)
Nota entrevistador: *Similar a las preguntas 6.1 y 6.2, cuál es el contexto político para el proceso del manejo integrado del paisaje, acá se pregunta sobre el nivel en que la iniciativa incluyó el cambio de políticas como una estrategia para alcanzar los paisajes integrales y multifuncionales.* ***Por lo tanto, si la iniciativa resultó en nuevas leyes de protección ambiental, subsidios o incentivos para la agricultura sostenible, etc., esos pueden ser mencionados.*** *Igualmente estamos interesados en aprender sobre* ***nuevos sistemas de gobernanza o políticas,*** *por lo tanto cambios en la tierra o tenencia de la tierra, procesos de toma de decisiones, nuevas entidades de gobernanzas como mancomunidades, etc.*

Hay algunos cambios adicionales en las políticas o gobernanza que usted considera se deberían de crear o implementar para apoyar los objetivos de la iniciativa?
(INTERPRETATIVA/ TRIANGULACIÓN)

SECCION 7: RESULTADOS Y EFECTIVIDAD DE LA INICIATIVA

Al comienzo de la conversación, usted identificó tres [O la cantidad que mencionó en la pregunta 3.2] objetivos de la iniciativa de paisaje. Ahora nos gustaría conocer su opinión sobre la efectividad de la iniciativa en alcanzar cada objetivo. Me gustaría preguntarle en una escala del 1 al 7 cual fue el nivel de efectividad de cada objetivo, siendo. Luego me gustaría conocer por que les dio esa calificación (indicadores y/o resultado de la iniciaitva. Vamos a comenzar con el primer objetivo [mencionarlos].
(INTERPRETATIVA/ ¿? TODOS)

Objetivo (ver ¿? 3.2)	Nivel efectividad (**7** cuando se logró totalmente el objetivo, **4**	Por qué / cómo les asignó ese valor? Usó indicadores o percepción?. (trate de comprobar si los resultados son claramente atribuibles

	cuando se logró parcialmente y **1** cuando no hubo ningún progreso)	propiamente a la iniciativa)
4)		

Que tan efectiva ha sido la iniciativa reuniendo a los diferentes actores para incrementar la cooperación y resolver los conflictos para alcanzar los múltiples objetivos en el paisaje?
(INTERPRETATIVA/ ¿? TODOS)
Nota entrevistador: *Esta es una pregunta abierta. Buscamos entender de igual manera la parte exitosa y no exitosa del proceso del manejo del paisaje con múltiples actores. Queremos conocer si la iniciativa ayudó a incrementar la coordinación y colaboración entre sectores (p.e. agricultura, forestal, agua, salud) y a diferentes escalas (p.e. finca, villas, distritos, cuenca, región)*

Me gustaría preguntarle sobre los beneficios e inconvenientes de trabajar a escala de paisaje. De qué manera el enfoque de paisaje de la iniciativa ayudó a los actores a entender y a abordar mejor diferentes temáticas, problemas y retos en el paisaje? [Pausa para la persona responder, continuar con:] De qué manera el enfoque de paisaje dificultó el logro de objetivos claves?
(INTERPRETATIVA/ ¿? TODOS)
Nota entrevistador: *Estamos tratando de entender si el enfoque de manejo integral de paisajes (p.e. reuniendo personas de diferentes sectores y en diferentes escalas) ayuda a los actores a encontrar un sentido común entre los diferentes intereses, o áreas de negociación de discordia o conflicto?. Igualmente queremos entender si el enfoque de paisaje pudo haber distraído la atención de puntos claves locales, si este enfoque es considerado irrelevante por algunos actores que están más preocupados por asuntos sectoriales o locales, o si el enfoque de paisaje creó problemas muy grandes o complejos de resolver.*

Finalmente, me gustaría preguntarle sobre el impacto de la iniciativa en algunos grupos comunitarios en el paisaje. Me podría decir si la iniciativa benefició, no tuvo ningún efecto, o perjudicó a cada uno de los siguientes grupos? [Omitir los que no aplican para paisaje]
(INTERPRETATIVA/ ¿? TODOS)

Grupos	Benefici ó	No tuvo ningún efecto	Perjudi có
Pequeños productores y/o ganaderos			
Medianos productores y/o ganaderos			
Grandes productores y/o ganaderos beneficio			
Personas sin tierra (p.e como los trabajadores de las fincas, arrendatarios, “parceros”, “tala y quema”)			
Comerciantes e industriales agropecuarios.			
Responsables / administradores del bosque			
Comunidades nativas dependientes del bosque			

Grupos	Benefició	No tuvo ningún efecto	Perjudicó
Mujeres.			
Comunidades viviendo en los pueblos y/o ciudades (no involucradas con la agricultura / forestería).			
Más ricos:			
Más pobres:			
Otros:			

<u>SECCION 8</u>: LECCIONES APRENDIDAS Y REFLEXÓN GENERAL

Finalmente, nos gustaría solicitarle reflexionar críticamente sobre la iniciativa y compartir algunas de las lecciones que usted aprendió, y pensamientos sobre cómo las iniciativas de paisaje, como la actual, pueden ser más efectivas en el futuro.

Cuál fue el aspecto más exitoso de la iniciativa?
(INTERPRETATIVA/ ¿? TODOS, menos al que llenó la encuesta del TIER 1)

Cuál fue el aspecto menos exitoso de la iniciativa?
(INTERPRETATIVA/ ¿? TODOS, menos al que llenó la encuesta del TIER 1)

Si tuviera más plata para diseñar e implementar esta iniciativa qué haría diferente?
(INTERPRETATIVA/ ¿? TODOS, menos al que llenó la encuesta del TIER 1)
Realizaría un monitoreo y control más eficientes

De acuerdo a su experiencia, qué consejo le daría a sus colegas que están comenzando una iniciativa de paisaje?
(INTERPRETATIVA/ ¿? TODOS)
<u>Nota entrevistador:</u> *Esta pregunta está hecha para combinar las dos preguntas anteriores en términos de las lecciones aprendidas y los aspectos de la iniciativa que son replicables en cualquier lugar. Si el entrevistado no parece responder la pregunta de esta manera, siéntase libre de redirigirlo.*

[Termine agradeciendo a la persona por su participación y déjele saber que recibirá una copia del estudio cuando éste termine]

APPENDIX D

Description of each factor and its parameters, including the maximum values, minimum values and equations used to create the theoretical dataset. HB: handbook·

	RUSLE (S=C•R•K•L•S) ($tonf \cdot acre^{-1} \cdot year^{-1}$)*		
Factors / Parameters	**Max**	**Min**	**Equations / Max and min values sources**
Cover - Management factor C (dimensionless)			
C factor	1	0	C= PLU•CC•SC•S
PLU (Prior Land Use)	1	0	PLU=Cf•Cb•EXP[(-Cur•Bur)+(Cus•Bus/Cf^Cuf)]
Cf: surface soil consolidation factor (decay exponentially when soil is left undisturbed)	1	0.05	"The value of Cf for freshly tilled conditions is 1. If the soil is left undisturbed, this value decays exponentially to 0.45 over 7 yr, or over some other length of time specified by the user". HB 703
Bur: Mass density of live and dead roots found in the upper inch of soil ($lbacre^{-1}in^{-1}$)	1,750	345	Based on the RUSLE2 CROP dataset and HB 703 tables
Bus: mass density of incorporate surface residue in the upper inch of soil ($lbacre^{-1}in^{-1}$)	1,700	0	Based on the RUSLE2 CROP dataset and HB 703 tables
Cuf: impact of soil consolidation on the relative effectiveness of incorporated residue		0.5	Describe the relative effectiveness of subsurface biomass in reducing erosion. The values were calibrated using information from Van Liew and Saxton (1983), values from table 5 and 5d in
Cb: relative effectiveness of subsurface residue in consolidation		0.951	Agricultural Handbook 537 (Wischmeier and Smith, 1978), and an extensive data set collected from a broad series of no-till experiments. hb 703
Cur: calibration coefficient indicating the impacts of the subsurface residues (acre in lb^{-1})	0.00398	0.00199	
Cus: calibration coefficient indicating the impacts of the subsurface residues (acre in lb^{-1})	0.000832	0.00042	
CC (Canopy cover)	1	0	CC= 1-Fc•exp(-0.1•H)
Fc: Fraction of land surface covered by canopy	1	0.05	HB 703
H: distance that rain drops fall after striking the canopy (ft)	33	0.5	Data based on the listed crops on the HB 703
SC (Surface cover)			SC=exp[-b•Sp•(0.24/Ru)^0.08]
b: empirical coefficient. indicate the effectiveness of surface cover in reducing soil loss	0.07	0.024	Extreme values from the different b values reported by several authors: Laflen et al., (1980) and Laflen and Colvin (1981) b=0.030 to 0.070 for row crops; Dickey et al., (1983) b=0.024-0.032 for small grains; b>0.05 small grains in northwestern wheat and range region; Simanton et al., (1984) b= 0.039 for rangeland. HB 703
Sp: Percentage of land area covered by surface cover (crop residue, rocks, cryotogams and other no erodible material that is in direct contact with the soil surface	100	0.1	HB 703

Ru: surface roughness in in	1.9	0.25	From table 5-5 in HB 703, In Figure 4-3 it is indicated that a Ru =4 indicate more roughness than from most primarily tillage operations. It is kept the value of 2 because Wischmeier and Smith (1978) affirms that the USLE equation estimate accurately soil loss for consistent cropping and management systems that have been represented in the erosion plot studies
SR (Surface roughness)	1	0.9	SR=exp[-0.66(Ru-0.24)]
Rainfall-runoff erosive factor R (100 foot•tonf•inch•acre^{-1} •hour^{-1}•year^{-1})**			
R factor			R = ∑(j=1 to j=n)E•I30
I30 (in/hr): Erosive rain Intensity	3.00	0.50	The limit of 3in/h is because median drop size does not continue to increase when intensities exceed this threshold (Carter et al., 1974). The limit for rain showers less than 0.5in and separated from other rain periods by more than 6 h are omitted, because these light rains are usually too small for practical significance and that, collectively, they have little effect on the distribution of the annual EI or erosion. Also reduce time consuming processing EI. HB 703
E (100ft tonf acre^{-1} in^{-1}): Kinematic Energy	10.81	6.80	E = (1099•(1-0.72•EXP($^{-1}$.27•I)))/100
j (no storm / yr): No events per year	50.00	5.00	HB 703
Soil - erodibility factor K (tonf•acre•hour•100^{-1}acre^{-1} foot^{-1} tonf^{-1} inch^{-1})***			
K factor			K= [2.1•〖10〗^(-4) (12-OM) M^1.14+3.25• (s-2)+2.5• (p-3)]/100
OM%: Organic matter	4.00	-	Based on the nomograph HB 537
Clay% (<0.002 mm)	40.00	10.00	
Silt% (0.002 - 0.1 mm)	70.00	10.00	Based on the nomograph HB 537
Sand% (0.1 - 2 mm)	70.00	10.00	Based on the nomograph HB 537
p: Permeability	5	2	Wischmeier and Smith (1978) affirms that the
s: Structure class	4	1	USLE equation estimate accurately soil loss “for medium – textured soil”
M			M=(%Silt +%Very fine sand)(100-%Clay);
Topographic factor (dimensionless)			
Slope length			L= (λ/72.6)^m
Slope steepness	10	2	S= IF(θ<5, (10.8•sinθ+0.03), (16.8•sinθ-0.5)) θ: slope angle in degrees
λ: Slope length (ft). Horizontal projection	400	10	Soil runoff will usually concentrate in less than 400ft, which is a practical slope length limit in many situations, although longer slope lengths of up to 1,000 ft are occasionally found. The equation for S can’t be applied to slopes shorter than 15 ft
m: a variable slope length exponent	0.44	0.17	m=β/(1+β)
β: ratio of rill erosion to inter-rill erosion	0.80	0.21	β=(sinθ/0.0896)/[3•(sinθ)^0.8+0.56]

*Conversion to SI system: 2.242 metric ton•ha^{-1}•yr^{-1}

**Conversion to SI system: 17.02 megajoule•millimeter•ha^{-1}•hour^{-1}•year^{-1}

*** Conversion to SI system: 0.1317 metric ton•ha•hour•ha^{-1}•megajoule^{-1}•millimeter^{-1}

APPENDIX E

Description of the selected soil conservation practices in terms on the mechanism to retain soil, pros and cons, and factors that limit the efficacy of the practices.

	Mulch	Cover crops	Hedgerow	Agroforestry
Mechanism	Mitigates the impact of the rain drops, reduction soil detachment and increase water infiltration (Donjadee & Chinnarasri, 2012).	The root system offers resistance to the overland flow (Edwards & Burney, 2005) Also, offers same protection as Mulch	Reduce Runoff, promotes deposition and water infiltration	Mitigates the impact of the rain drops, protect soil and return nutrients via litter or mulch material Deep roots favors water infiltration and reduce runoff (Niemeyer et al., 2013)
Pros	Reduce soil loss and runoff (Adekalu, Okunade, & Osunbitan, 2006) Mulch may form dams and build up hollows which delays the afterflow (Döring et al., 2005) Finer mulch texture cover higher land with not to moderate effects on soil moisture nor crop yield (Döring et al., 2005) Improves soil moisture, moderate soil thermal regime, improves soil aeration, promotes biological activity, improves soil structure, add organic matter and nutrients, reduction N loss (Acharya, Hati, & Bandyopadhyay, 2005)	Incorporate organic matter and nutrients to the soil (Edwards & Burney, 2005) Prevent nutrient loss (Ruiz-Colmenero, Bienes, & Marques, 2011) May form positive associations with crops providing key nutrients and improving main crop yield (i,e, total N content) (Armecin et al, 2005) Protect soils from extreme climatic fluctuations, improves soil aggregates (Armecin et al., 2005) In the long-run it facilitates water infiltration, increases soil organic carbon and aggregate stability, (Ruiz-Colmenero et al., 2013) Result in higher macrofauna density and biomass, higher density of facultative phytophagous, bacterial-feeding and predatory nematodes, and lower density of obligatory (Blanchart et al., 2006) Helps to solve weed management (Erenstein, 2003)	Facilitates terraces formation through time (Lin et al., 2009) Provides fodder for ruminants, mulch or grains (Angima et al., 2002; Dinh et al., 2014) Increase crop yields due to the control of soil loss and the improvement of soil bulk density, gravimetric moisture content and infiltration parameters (Oshunsanya, 2013) Increase soil organic matter, total nitrogen and total phosphorus contents (Bu et al., 2009)	More profitable than conventional agriculture (Neupane & Thapa, 2001) Deep-rooted trees reduce the environmental risk by NO3-N pollution and increased water retention capacity of subsurface soil (Wang, Zhang, Lin, & Zepp, 2011)
Cons	Low levels of mulch may have no effect on weeds, weed cover and above ground biomass of weeds (Döring et al., 2005) If poor planned it can affect sowing or tillage, increase diseases or pest, and limit seedling emergence (Acharya, Hati, Bandyopadhyay, 2004)	Competition with the main crop for water and nutrients may reduction main crop yields (Ruiz-Colmenero, Bienes, & Marques, 2011)	After long periods the portions below of the plant hedgerows can also suffer severe erosion (Chaowen et al., 2007) Can compete with main crop for nutrients and light (Dinh et al., 2014; Oshunsanya, 2013), Cutting cost to avoid crop competition increase farm labor (Kinama et al., 2007)	Lower trunk biomass and slower tree growth due to competition with crops during establishment (Ong et al., 2000) Superficial roots and high demand for water affect crop yields (Ong et al., 2000)
Efficacy reduced by	Slope gradient, soil type, mulch type and dominant soil process (Smets, Poesen, & Knapen, 2008) Dislodged by wind or frequent runoff (Edwards & Burney, 2005)	Quantity and quality of biomass (Edwards & Burney, 2005) Cover type (Ruiz-Colmenero, Bienes, & Marques, 2011) Insecure land tenure, need of short-term outcomes (Erenstein, 2003)	Low tillering ability and low root densities (Rodriguez, 1997; Xiao et al., 2011; Xiao et al., 2012) Steeper slopes and higher rainfall intensities (Xiao, et al., 2011) Tillage technologies (Thapa, Cassel, & Garrity, 1999)	Insecure land tenure, land fragmentation, poor extension service, limited technical know-how, and unavailability of planting materials (Neupane & Thapa, 2001) Mulch with poor nutrients quality and complex decomposition patterns (Heineman et al., 1997)

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APPENDIX F

Establishment and maintenance cost for the selected soil conservation practices. Some cost varies depending the slope steepness (gentle <15%, moderate 15-30%, steep >15%). Cost are established at pixel level (900m2).WD: Working days

					Hedgerow				
	<15%, 60 lineal m			15-30%, 90lineal m			>15%, 180lineal m		
Establishment	Qty	$	Total ($/ha)	Qty	$	Total ($/ha)	Qty	$	Total ($/ha)
WD*	4.4	18.0	79.1	8.0	18.0	143.8	14.0	18.0	251.6
Seeds (kg)	10.0	5.0	50.0	18.2	5.0	90.9	31.8	5.0	159.1
Maintenance (y)									
WD	1.1	18.0	19.8	2.0	18.0	35.9	3.5	18.0	62.9
Total			**148.8**			**270.6**			**473.6**
	Agroforestry high density			Agroforestry low density					
	277 trees**			62 trees***					
Establishment	Qty	$	Total ($/ha)	Qty	$	Total ($/ha)			
WD	13.1	18.0	235.7	3.2	18.0	57.7			
Seeds (kg)****	0.06	96.0	6.7	0.01	87.0	1.4			
Maintenance (y)									
WD	13.1	18.0	235.7	3.2	18.0	57.7			
Total			**462.2**			**116.7**			
	Mulch			Cover crops					
	<15%			>15%					
Establishment	Qty	$	Total ($/ha)	Qty	$	Total ($/ha)			
WD	8.5	18.0	153.1	4.3	18.0	76.5			
Seeds (kg)				51.6	5.0	258.1			
Animal (day)	1.4	20.0	28.4						
Maintenance (y)									
WD	7.1	18.0	127.6	7.1	18.0	127.6			
Total			**309.1**			**462.2**			

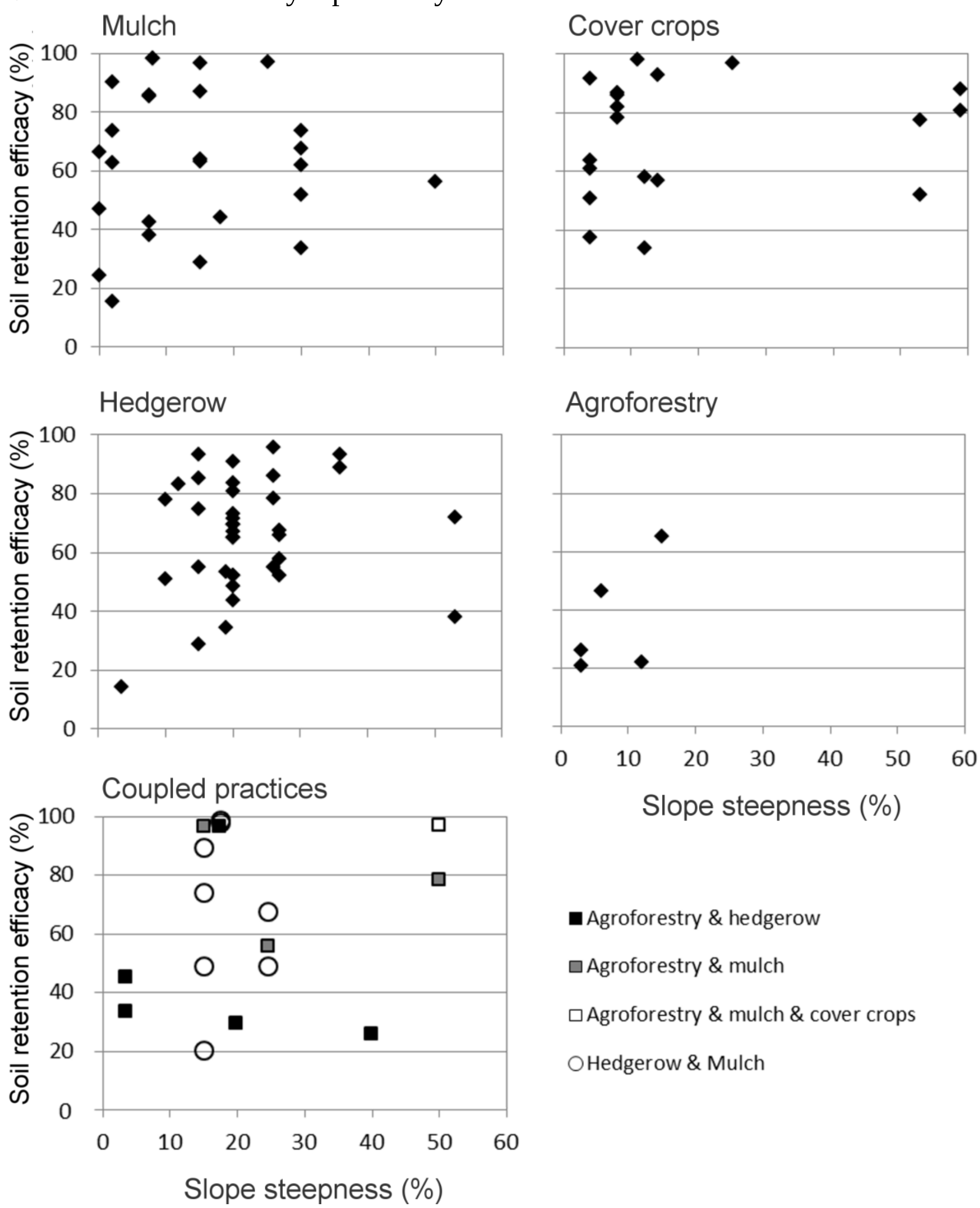
* Minimum wage in Costa Rica for 2014 is ₡8944.51 according to the Ministry of labor and Social Security (http://www.mtss.go.cr/images/stories/Lista_salarios-2014-1semestre.pdf). We used the average value reported in Oanda to convert it from Costa Rica currency to US dollar (₡497.677=$1).
**Highest tree density usually associated to pastures. Density reported in the agroforestry guideline of the Costa Rican national office (http://onfcr.org/media/uploads/documents/guia_saf_onf_para_web.pdf).
*** Rainforest Alliance certified coffee farms number of trees in average (http://www.rainforest-alliance.org/about/documents/tensie-25anniversary-presentation.pdf)
****One kilogram of mixed seeds of endangered trees species contain in average 19,950 viable seeds per kilogram.

APPENDIX G

Results from the literature review to estimate the soil retention efficacy of each soil conservation practice we modeled.

We conducted a literature review to estimate the soil retention efficacy (SRE) of each soil conservation practice. A larger numbers of the assessed experiments were conducted at gentle slopes (Figure 1).

Figure 1. Soil retention efficacy reported by 30 studies and 107 observations



We estimated SRE since the reported combinations of soil conservations practices in the reviewed experiments did not match the combinations of our ideal cropping systems. Also, we consider the high variability of the reported SRE and decided to choose a conservative method. The estimated SRE is the sum of the minimum reported SRE for each soil conservation practice in each ideal cropping system. Ideal cropping systems at slopes higher than 30% should not incorporate mulching practices but cover crops. We used the average estimated SRE for ideal cropping systems using mulching or cover crops (i.e. perennial avg =59%) (Table 1). Reported SRE corresponds to seventeen experiments also with highly variable results. Table 1 also shows the minimum value reported for the combinations reported in the reviewed research.

Table 1. Minimum reported and estimated soil retention efficacy (SRE) for coupled soil conservation practices. Reported soil retention efficacy corresponds to the minimum reported value in seventeen experiments. Estimated SRE is the sum of the minimum SRE reported for each soil conservation practice.

Coupled soil conservation practices	**Mulch**	**Cover crops**	**Hedgerow**	**Agroforestry**	**SRE**
Reported SRE			X	X	26
	X			X	56
	X	X		X	97
	X		X		20
Estimated SRE per ideal cropping system					
Perennial		X	X	X	69
	X		X	X	50
Annual		X	X	X	69
	X		X	X	50
Semi-perennial			X	X	35
Pasture			X	X	35

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